DOCUMENT RESUME

ED 110 408 SO 008 562

AUTHOR	De Tray, Dennis N.
TITLE	The Interaction Between Parent Investment in Children and Family Size: An Economic Analysis.
INSTITUTION	Rand Corp., Santa Monica, Calif.
SPONS AGENCY	Rockefeller Foundation, New York, N.Y.
PUB DATE	Apr 72
NOTE	75p.
EDRS PRICE	MF-$0.76 HC-$3.32 PLUS POSTAGE
DESCRIPTORS	*Birth Rate; Children; Economic Factors; *Economic Research; Economics; *Family Planning; Family Resources; Parent Child Relationship; *Population Trends; *Socioeconomic Influences; Socioeconomic Status; Urban Population

ABSTRACT

A theoretical and empirical investigation of the family size decision is reported. The distinguishing feature of the study is its emphasis on the relationship between investment in and desired number of children. The basic argument is that in determining the level of benefits they want to receive from children and child-related activities, parents view additional investments in children and additional births as substitutes. The data are drawn from a 1960 cross section of United States with counties as the units of observation. Female earnings are the most important determinant of completed family size in terms of both magnitude of effect and statistical significance. Other variables having a significant negative effect on childbirth are female education and the degree to which a county is urban. On the other hand, median value of housing and male earnings both exert a positive influence on desired numbers of children. When economic differences are accounted for, race plays virtually no role in determining family size. (Author/DE)

R-1003-RF

April 1972

The Interaction Between Parent Investment in Children and Family Size: An Economic Analysis

Dennis N. De Tray

A Report prepared under a Grant from

THE ROCKEFELLER FOUNDATION

Rand
SANTA MONICA, CA 90406

This report was prepared for The Rockefeller Foundation under Grant No. RF-71001 (E7112). Views or conclusions contained in this study should not be interpreted as representing the official opinion or policy of Rand or of The Rockefeller Foundation.

Bibliographies of Selected Rand Publications

Rand maintains a number of special subject bibliographies containing abstracts of Rand publications in fields of wide current interest. The following bibliographies are available upon request:

Aerodynamics • Africa • Arms Control • China • Civil Defense
Combinatorics • Communication Satellites • Communication Systems
Computer Simulation • Computing Technology • Decisionmaking
Delphi and Long-range Forecasting • East-West Trade • Education
Game Theory • Health-related Research • Human Resources
Latin America • Linguistics • Maintenance • Middle East
Policy Sciences • Pollution • Population
Privacy in the Computer Age • Probability • Program Budgeting
Public Safety • SIMSCRIPT and Its Applications • Southeast Asia
Space Technology and Planning • Statistics • Systems Analysis
Television • Transportation • Urban Problems • USSR/East Europe
Water Resources • Weapon Systems Acquisition
Weather Forecasting and Control

To obtain copies of these bibliographies, and to receive information on how to obtain copies of individual publications, write to: Publications Department, Rand, 1700 Main Street, Santa Monica, California 90406.

5

Published by The Rand Corporation

[redacted]

PREFACE

This report explores the strengths and weaknesses of an economic model of the interrelationships between the choices parents make on the number of children they desire and the amount of resources they want to invest in each of their offspring. Earlier Rand studies have drawn attention to the close association between fertility in low income countries and differences in child labor practices and school attendance patterns, but the analysis of fertility decisions has concentrated on the numbers of children women bear.[1] It is becoming ever clearer, however, that to understand the dynamics of change that precipitate a reduction in fertility, one must also account for the closely associated decision of parents to withdraw their children from the work force and invest in their schooling. The joint dependency of the fertility and schooling decisions must become a central feature of social science research if we are to improve our understanding of the determinants of fertility in low income nations. Although the empirical test of the model developed here is limited to data from the United States, the implications for research and policy in the Third World are linked to the central role attributed to education -- both parental and child -- in influencing desired family size decisions.

This work was completed under a grant from The Rockefeller Foundation to support research on the Economics of Fertility Determination and Family Behavior.

---

[1] Donald O'Hara, *Changes in Mortality Levels and Family Decisions Regarding Children*, R-914-RF, February 1972; Julie DaVanzo, *Family Formation in Chile, 1960*, R-830-AID, December 1971; T. Paul Schultz, *Evaluation of Population Policies: A Framework for Analysis and Its Application to Taiwan's Family Planning Program*, R-643-AID, June 1971; A. J. Harman, *Fertility and Economic Behavior of Families in the Philippines*, RM-6385-AID, September 1970; Marc Nerlove and T. Paul Schultz, *Love and Life Between the Censuses: A Model of Family Decision Making in Puerto Rico, 1950-1960*, RM-6322-AID, September 1970; Y. Ben-Porath, *Fertility in Israel, An Economist's Interpretation: Differentials and Trends, 1950-1970*, RM-5981-FF, August 1970; T. Paul Schultz (assisted by Julie DaVanzo), *Fertility Patterns and Their Determinants in the Arab Middle East*, RM-5978-FF, May 1970; T. Paul Schultz, *Population Growth and Internal Migration in Colombia*, RM-5765-RC/AID, July 1969; T. Paul Schultz, *A Family Planning Hypothesis: Some Empirical Evidence from Puerto Rico*, RM-5405-RC/AID, December 1967.

SUMMARY

This report presents a theoretical and empirical investigation of certain aspects of the family size decision. The distinguishing feature of the study is its emphasis on the relationship between investment in and desired number of children. The crux of the argument is that in determining the level of benefits they want to receive from children and child related activities parents view additional investments in children and additional births as substitutes.

The theoretical model presented here is a further development and application of recent extensions of household production theory. Proponents of this approach argue that households do not derive utility directly from purchased market goods and services but must first transform these factors into more basic items of consumption called "household commodities." One such commodity, the focus of this study, is "child services." The stock of child services is postulated to be a function of two home-produced inputs, numbers of children and child quality (investment in children). The model's special characteristics are twofold. First, by definition, numbers of children and child quality are substitutes in the production of child services; second, the income elasticities for both inputs are assumed to be equal. The theoretical model yields two derived demand equations, one for numbers of children and one for quality per child.

A less rigorous but more detailed discussion establishes reasonable bounds on some of the unknown parameters of the model by referring to other studies of household behavior. The first part of the discussion focuses on the relative weights of husband's and wife's time in production of child services, and the second introduces the value of child time and infant mortality into the model.

A preliminary attempt to validate the model empirically estimates derived demand equations for numbers of children and expected public school investment as a proxy for quality per child. The data are drawn from a 1960 cross-section of the United States with counties as the

units of observation. In general, the estimated equations are satisfactory in that the coefficients conform to prior expectations, and the proportions of the variation explained by the independent variables are respectable.

The regressions on both numbers of children and quality per child imply that production of child services is dominated by women. The role of men seems primarily that of suppliers of goods and services, but this part of the picture is still unclear.

Female earnings are the most important determinant of completed family size in terms of both magnitude of effect and statistical significance. Other variables having a significant negative effect on children ever born are female education and the degree to which a county is urban. On the other hand, median value of housing (a proxy for full wealth) and male earnings both exert a positive influence on desired numbers of children. In addition, the children-ever-born regressions indicate that (1) the full wealth elasticity for numbers of children is probably positive, but small; and (2) when economic differences are accounted for, race plays virtually no role in determining family size.

The regressions on quality per child are weaker than those for numbers of children. In part, this weakness must stem from the proxy variable expected public school investment, which undoubtedly contains large errors of measurement. The principal findings from these regressions are that female (wife's) education increases the relative efficiency with which child quality is produced, thereby reducing its effective real price, and that the derived income elasticities for numbers of children and for child quality appear to be similar in size. Also, although not a prediction of the theory, the behavior of the rural and race measures indicate that there may be little difference in tastes for child quality between either rural and urban residents or whites and non-whites, other things equal.

ACKNOWLEDGMENTS

This investigation is a summary and extension of research begun while the author was a graduate student at the University of Chicago. T. W. Schultz, Gary Becker, Marc Nerlove, H. Gregg Lewis, and Mary Jean Bowman, all of the University of Chicago, were major contributors to this report. James P. Smith of City University of New York and Alan Freiden of Virginia Polytechnic Institute commented on earlier versions. At Rand, T. Paul Schultz did much to improve the exposition and to clarify a number of points. Yoram Ben-Porath of Harvard and Hebrew University, and William P. Butz of Rand also critically read and commented on earlier drafts. In addition, Rand colleagues Eva Ewing, Alvin Harman, and Charles Phelps, and Rand consultant Glen Cain of the University of Wisconsin contributed many useful suggestions (not all of which could be included in this report) during the review of this work. Any remaining errors are solely the author's responsibility.

The preliminary phases of this research were supported by grants to the Department of Economics, University of Chicago, from the National Institute of Mental Health and The Rockefeller Foundation.

CONTENTS

LIST OF TABLES

I. INTRODUCTION

The past decade has seen a substantial increase in the economic analysis of phenomena outside the traditional realm of economics. This report is an addition to the already sizable portion of these efforts that have been directed toward the determinants of desired fertility and family size.[1]

The model presented in Section II is a further development and application of recent extensions of household production theory;[2] in fact, much of the analytical power of the model stems from its emphasis on the production aspects of household activity. The theoretical basis for the household production function model is the proposition that the traditional conception of the household as a utility maximizing agency is incomplete. In classical economic theory, households are assumed to derive utility directly from purchased market goods and services. Proponents of the household production model argue that this assumption is both inaccurate and misleading, that, in fact, households derive utility from more basic units of consumption called "household commodities." Household commodities are not purchased in the market place as such but are produced by the household under a given household technology, with inputs of purchased market goods and services and the time of one or more household members. These commodities are not traded in the market place and thus have no explicit market price. However, since each commodity is produced with varying proportions of the household's scarce resources, each has a shadow price that depends in part on the technology underlying household production and in part on household consumption patterns.

This approach emphasizes that household production-consumption can seldom occur without inputs of time by the household members.

---

[1]See, for example, Becker (1960), Schultz (1969), Willis (1969), Nerlove and Schultz (1970), Ben-Porath (1970), Michael (1970), as well as those listed in the Preface.

[2]The generic term for these extensions is "household production function model." The seminal articles are those of Becker (1965) and Lancaster (1966).

Important determinants of the commodity shadow prices are the time intensity of the production processes, and the value (opportunity cost) of time. Households whose members have high market wage rates, for example, will find the production of time-intensive household commodities costly and, to the extent technically possible, will substitute market goods and services for their own time in that production. Moreover, they will tend to consume more of the household commodities that are market-goods-and-services-intensive than will households whose time value is not so high.

The work presented here is concerned with two problems. The first is the degree to which pure economic theory can, or cannot, predict changes in completed fertility. The second, and the major emphasis of the study, is the way in which households produce the household commodity "child services."[1] I argue that households can increase their production of child services either by increasing numbers of children (quantity) or by increasing the resource investment (quality) in existing children. Thus, quantity and quality are postulated to be substitutes in the household's production function for child services.

Section II presents an economic model of desired family size that emphasizes the substitutability of numbers of children and child quality. Section III discusses several of the important parameters of the model at a less rigorous but more detailed level. Section IV contains an empirical formulation of the model based on a cross-section of U.S. counties.

---

[1]One could also think of this commodity as "enjoying one's family" as Michael (1970) does, but the activities implicit in that term are somewhat broader than those for child services.

II. TOWARD AN ECONOMIC MODEL OF DESIRED FAMILY SIZE

Children are viewed in this model as home-produced durable assets from which parents consume a flow of services. This flow varies with both the biological units of children (numbers) and with the resource intensity (quality) with which the children are raised. No distinction is made between the consumer durable aspects and the producer durable aspects of children in the formal model, alt[illegible] effect of a positive opportunity cost for child time (chil[illegible]aving value as producer durables) is explored in Section III.

Assume that all inputs into the various production processes are perfectly divisible and that all production functions are homogeneous of degree one.[1] The utility function underlying household behavior has as arguments "child services" and a composite commodity, Z, representing all other household production-consumption activities. That is:

$$U = U(S,Z) \tag{1}$$

where S is the stock of child services.

This study is concerned only with the household's determination of the desired stock of children and not with an optimal timing pattern. The model is, therefore, of the one-period, static-state variety in which the household is assumed to make all its lifetime decisions at one point in time and to have correctly gauged lifetime conditions. Strictly speaking, it is not S but the flow of services from S that enter the household utility function. However, in order to write the utility function as in Equation (1), S need only be measured in "efficiency units," so that total services derived are proportional to the stock.

[1]The analysis is complicated, but the major results remain unchanged for homogeneous production functions of degrees other than one.

The amount of Z produced and consumed by the household is a function of the quantities of time and purchased goods the household allocates to that production process, the state of household technology, and the efficiency with which the production process is undertaken. The inputs may be classified into three categories: male (husband's) t), female (wife's) time (t_f), and market goods and services (x). The efficiency effect is assumed to be a function of the environment in which production takes place, which, in turn, depends primarily on the education of the husband and wife.

The production of S is not accomplished directly through inputs of time and goods but by way of two home-produced factors, numbers of children (C) and child quality (Q).[2] The complete household production framework can be summarized by the following four equations:[3]

$$S = S(C,Q) \tag{2}$$

$$C = C(t_{m,C},\ t_{f,C},\ x_C;\ \beta,\gamma) \tag{3}$$

$$Q = Q(t_{m,Q},\ t_{f,Q},\ x_Q;\ \beta,\gamma) \tag{4}$$

$$Z = Z(t_{m,Z},\ t_{f,Z},\ x_Z;\ \beta,\gamma) \tag{5}$$

---

[1] To simplify the model, households are assumed to consist of a husband, a wife, and children only; that is, other adult members are not considered in the analysis. Also, throughout this study, the terms "male time" and "female time" are used interchangeably with "husband's time" and "wife's time" and should not be confused with *hired* male and female time.

[2] For this discussion, quality may be thought of as the resource intensity with which children are produced. The same notion is found in both Becker (1960), and Michael (1970).

[3] Note that the form of the equations implies that each production process is independent; that is, joint production is ruled out. Given the previous assumption of perfectly divisible inputs, this is not a further restriction of the model (see Grossman, 1971). However, since the earlier assumption is unrealistic in certain important respects, Section III mentions possible effects of externalities, joint production, and so on, although the model is not formally amended to take these factors into account.

where

$t_{i,j}$ = total time of the ith household member in the production of the jth commodity or input (i = male or female, and j = Z, C or Q).

β = husband's efficiency factor.

γ = wife's efficiency factor.

x_j = market goods and services in the jth production process.

The form of the production framework may, at first, seem arbitrary in that C and Q might well be viewed as household commodities, thus eliminating Equation (2). However, the relationship between C and Z would then be conceptually similar to that between C and Q. The model is formulated to emphasize that this may not be the case; that is, a special relationship exists between C and Q that does not exist between C and any of the other household commodities. As the model is developed the framework will be seen to have special characteristics, and in at least one important sense it has a testable prediction that separates it from alternative forms.

In arriving at the desired lifetime levels of S and Z, households maximize Equation (1) subject not only to the technological constraint implied by Equations (2) through (5) but also to the total available lifetime resources. With respect to market goods and services, the household can spend no more than the total earnings of all members plus any initial endowment or wealth transfers (inheritance, dowries, and so on). That is:

$$x_S \cdot p_S + x_Z \cdot p_Z \leq e_m + e_f + V \tag{6}$$

where

x_j = market goods and services in the jth production process.

p_j = per unit price of x_j.

e_i = lifetime market (wage) earnings of the ith household member.

V = non-wage related income.

The household is also constrained in the amount of time available for work and household production. If T_m and T_f represent the total amount of time available to the husband and wife respectively, then:

$$\left.\begin{aligned} T_m &= t_{m,W} + t_{m,S} + t_{m,Z} \\ T_f &= t_{f,W} + t_{f,S} + t_{f,Z} \end{aligned}\right\} \qquad (7)$$

where $t_{i,j}$, as before, is the time of the ith household member in the jth production process, and W indicates time spent in the market place (working).

Since time can be exchanged for goods at the market wage rate, the two constraints (Equations (6) and (7)) can be combined into the following "full wealth" or lifetime resource constraint:

$$\begin{aligned} R &= \pi_Z \cdot Z + \pi_S \cdot S \\ &= T_m \cdot w_m + T_f \cdot w_f + V \end{aligned} \qquad (8)$$

where

R = household full wealth.

π_j = shadow price to the household of the jth commodity.

w_m = male lifetime wage rate (per unit time).

w_f = female lifetime wage rate (per unit time).

The shadow prices for S and Z are a function of both the time and the purchased goods resource requirements for each of these household commodities.[1] Since marginal products are constant in functions that are homogeneous of the first degree, the πs are the sum, in value terms, of the per unit production requirements (for given input prices) of market goods and services and male and female time for each commodity.[2]

The framework set out above is structured to emphasize the possibility that households can substitute quality for numbers of children in their production of child services. It has also been left unrestricted to illustrate that even in the simplified framework of Equations (1)

---

[1]And, of course, the household's production functions and consumption set.

[2]For details of the breakdown of the πs, see Appendix A.

through (8), there are serious problems involved in predicting, *a priori*, changes in *numbers of children*.

The following equation, derived in detail in Appendix A, illustrates the complexity of determining changes in the demand for C for given changes in the exogenous or predetermined variables in the system.[1]

$$
\begin{aligned}
EC = {} & (V/R)\eta EV \\
& - \alpha_{x_C} \{\alpha[k\eta + (1-k)\sigma] + (1-\alpha)\sigma^*\} Ep_C \\
& + \alpha_{x_Q} (1-\alpha)[\sigma^* - k\eta - (1-k)\sigma] Ep_Q \\
& + \alpha_{x_Z} (1-k)(\sigma-\eta) Ep_Z \\
& + \{(1-\alpha)\sigma^*(\alpha_{t_{m,Q}} - \alpha_{t_{m,C}}) + (1-k)\sigma(\alpha_{t_{m,Z}} - \alpha_{t_{m,S}}) + (e_m/R)\eta\} Ew_m \\
& + \{(1-\alpha)\sigma^*(\alpha_{t_{f,Q}} - \alpha_{t_{f,C}}) + (1-k)\sigma(\alpha_{t_{f,Z}} - \alpha_{t_{f,S}}) + (e_f/R)\eta\} Ew_f \\
& + \{(1-\alpha)\sigma^*(\mu_{C,\beta} - \mu_{Q,\beta}) + (1-k)\sigma(\mu_{S,\beta} - \mu_{Z,\beta}) + \eta[k\mu_{S,\beta} + (1-k)\mu_{Z,\beta}]\} E\beta \\
& + \{(1-\alpha)\sigma^*(\mu_{C,\gamma} - \mu_{Q,\gamma}) + (1-k)\sigma(\mu_{S,\gamma} - \mu_{Z,\gamma}) + \eta[k\mu_{S,\gamma} + (1-k)\mu_{Z,\gamma}]\} E\gamma \qquad (9)
\end{aligned}
$$

where

- E = d(log) operator (percent change).
- V = non-wage related income.
- R = full wealth.
- η = income elasticity of S, child services.
- α = the share of expenditures on C in total expenditures on S, that is, $(\pi_C \cdot C)/(\pi_S \cdot S)$.
- σ^* = the elasticity of substitution between C and Q in the production of S.

[1] A multitude of simultaneity problems have been brushed aside in this statement. Probably the most important is the interdependence of the market wage rate and the amount of time spent in the home, an especially severe problem for women. For a recent attempt to deal with this, see Nerlove and Schultz (1970).

$\alpha_{i,j}$ = the share of expenditures on the ith input in total expenditures on the jth output, where $i = x, t_m, t_f$ and $j = C, Q, Z, S$.

k = the share of total expenditures on S in full wealth, R.

σ = substitution elasticity between S and Z in U(S,Z).

p_i = price of market goods and services, x_i.

e_i = lifetime market earnings of the ith household member.

w_i = wage of the ith family member.

$\mu_{i,j}$ = the partial elasticity of the ith output with respect to the educational level of the jth household member, $i = C, Q, S, Z$, and $j = \beta, \gamma$.

Although formidable in appearance, this expression is not difficult to interpret. Each line represents the "weighted" effect on C of a change in one price, wealth, or productivity variable. Note that with the exception of two variables (V and p_C), the signs of the elasticity coefficients are ambiguous. An increase in V will increase the demand for C if C is a normal good, and an increase in p_C will lead to a reduction in the demand for C. All other coefficients depend on (1) the relative importance of the various inputs in the household production functions (as measured by their share in total production costs), (2) the degree to which male and female efficiency affect the various production functions, and (3) the relative household expenditures on S and Z. Unless one is willing to speculate on the magnitudes of these weights and efficiency effects, no *a priori* conclusions on fertility behavior can be drawn from the model even if all price and wealth variables were measurable.

A similar equation can be derived for child quality, with equally discouraging results. However, if the analysis is restricted to the *relative* amounts of C and Q, the situation becomes somewhat more tenable. Either from the above model, or more simply from a variant of the definition of the elasticity of substitution,[1] the following relationship

[1]The elasticity of substitution between C and Q can be written as

$$\sigma^* = \frac{E\ (Q/C)}{E\ (S_C/S_Q)}$$

Where S_Q and S_C are respectively the marginal products of Q and C in for the percentage change in the ratio of Q to C can be derived.

$$E(Q/C) = EQ\text{-}EC = \sigma^*[(\alpha_{t_{m,C}} - \alpha_{t_{m,Q}})Ew_m + (\alpha_{t_{f,C}} - \alpha_{t_{f,Q}})Ew_f$$

$$+ (\alpha_{x_C})Ep_C - (\alpha_{x_Q})Ep_Q - (\mu_{C,\beta} - \mu_{Q,\beta})E\beta$$

$$- (\mu_{C,\gamma} - \mu_{Q,\gamma})E\gamma] \tag{10}$$

where

- E = percent change (d(log) operator).
- σ^* = elasticity of substitution between C and Q in the production of S.
- $\alpha_{i,j}$ = share of expenditures on the ith input in total expenditures on the jth output, where $i = x, t_m, t_f$ and $j = C, Q$.
- w_i = wage of the ith household member.
- p_j = per unit price of x_j.
- $\mu_{i,j}$ = partial elasticity of the ith output with respect to the education of the jth household member, where $i = C, Q$, and $j = \beta, \gamma$.

If Equation (10) were estimatable, several interesting aspects of the model could be explored. Most important, the model, in particular the production function framework, assumes not only that Q and C are substitutes in the production of child services, but also that the derived pure income elasticities for these inputs are equal.[1] This

---

production of S. But, in equilibrium,

$$\frac{\pi_C}{\pi_Q} = \frac{S_C}{S_Q}$$

therefore,

$$\sigma^* = \frac{E(Q/C)}{E(\pi_C/\pi_Q)} = \frac{EQ\text{-}EC}{E\pi_C - E\pi_Q} \text{ or, } EQ\text{-}EC = \sigma^*(E\pi_C - E\pi_Q).$$

The rest of the proof consists simply of breaking $E\pi_C$ and $E\pi_Q$ into their constituent parts (see Appendix A for this last step).

[1]This result is, in a sense, a specific form of the more general "special relationship" postulated between C and Q.

assumption is of central importance to the model. It runs counter both to the findings of studies in the demand for household durables and to previous explanations of the observed negative relationship between numbers of children and household income.

With respect to the overall demand for durables, the household is usually observed having significantly higher income (wealth) elasticities for the quality component of items in this class than for the "numbers" component. An often cited example of this is the household's demand for automobiles: as incomes rise, households substitute Cadillacs for Chevrolets rather than increase their stock of Chevrolets. Why, then, formulate a model of desired family size that, by its very nature, violates this empirical "law"? The answer lies in the prior explanations given for the observed negative correlation between numbers of children and income. These explanations appeal to various forms of income effects as the cause of this relationship. This model is purposely structured to rule out explanations based on differential income effects and thus to place the entire weight of analysis on relative price effects. The formulation is legitimate because it has a clear, refutable hypothesis; that is, changes in household full wealth, holding all other factors constant, will leave the ratio of Q to C unaffected. Furthermore, it has the advantage of concentrating its explanatory power where economic theory has the most power -- pure price effects.

There are several other important features of the model. One is the separation of the price of time (wage rates) and education effects. The model emphasizes that education levels can affect household decisions, in particular number of desired children, independently of its well-known effect on wage rates. Thus it is possible to speak of the effect of a change in education levels holding time values constant. The most serious problems raised by this treatment are empirical rather than conceptual[1] and will be taken up later.

---

[1]To be sure, there are some conceptual problems; again (see footnote 1, p. 7) they involve the simultaneous nature of the household decisionmaking process. For example, a woman's decision on the number of years of schooling she chooses to receive in general will not be independent of the number of children she wants.

Another feature is that the husband and wife are treated symmetrically in this model. Both are permitted either to work in the market place or engage in home production (of commodities). Whether one, or both, chooses to specialize will depend on the various parameters of the model, especially on the wage of the husband relative to that of the wife and the value of each spouse's time in home production.

III. SUPPORTING EVIDENCE AND RELATED ISSUES

This section is devoted to a detailed but non-rigorous discussion of the important parameters of the model. Its purpose is to establish reasonable bounds on some of the unknown parameters. I first concentrate on those parameters associated with the adult members of the household (husband and wife) and then on child related characteristics.

ADULT TIME AND ADULT EDUCATION

Much of the ambiguity in the signs of the coefficients of Equation (9) stems from a lack of information on the relative weights of the various inputs. In the past, it has often been assumed (see, for example, Willis, 1969; Gardner, 1970) that since men spend, on the average, less of their time in the home than do women, male time is less important than female time in household production. This assumption is seldom questioned even though $t_f > t_m$ (the relative amounts of time in household production) does not imply that $\alpha_{t_f} > \alpha_{t_m}$ (the relative shares of time costs in household production). Since male wages are above female wages in most households,[1] men could contribute fewer hours to household production and still account for a larger fraction of total household production costs than do women.[2]

An even more generally accepted relationship is that male time in production of child services (however defined) is less important than female time.[3] This seems indisputable at early ages, say under 6, but one must be at least cautious in extending this proposition to lifetime considerations. In the notation of Equation (9), $\alpha_{t_{m,S}}$ and $\alpha_{t_{f,S}}$

---

[1] Based on the Office of Economic Opportunity's Survey of Economic Opportunity, the husband's wage exceeded that of the wife in 81 percent of the households in which both spouses were working.

[2] In fact, there is some indication in Ofek's (1971) work on the allocation of time by women that this may be true.

[3] Willis (1969), for example, assumes that the role of male time in production of child services is sufficiently small that it can be ignored.

are concerned with the *lifetime* allocation of time by husbands and wives and not merely time allocation during the first few years of the child's life. Fortunately, the labor force participation behavior of men and women does yield some insight into this problem.

The presence of children in the household has been observed to have a significant negative effect on both labor force participation of women and on the hours women work, but no such effect on the labor force behavior of men. In fact, in his work on the allocation of time by households, Smith (1970) found that an increase in the number of young children in the household increased the number of hours men worked per year, but decreased the number of hours women worked.[1] Therefore, unless husbands drastically reduce the amount of time allocated to other household production (Z) when children are present in the household, children are indeed more female time-intensive than male time-intensive.

The model further complicates the analysis of the role of time by assuming that children are produced with two time-using inputs, quality (Q) and numbers (C). Although direct evidence is scarce, there are some scattered indications of the importance of male and female time in the production of Q and C.

It is well documented that highly educated married women both participate to a greater extent in the labor force and work more hours when they do work than do married women with less schooling.[2] Both groups also withdraw time from the labor force when they have children, supporting the assumption that children are female time-intensive.[3] However, there are indications that the *rate* of withdrawal is not the same for women with different levels of education. If one looks at the gross relationship of hours worked per year by age, education, and sex, the following observations can be made. First, for husbands the higher the education level the larger the number of hours worked per year for each year worked; and, in general, the *patterns* of hours worked for

[1]A partial summary of the evidence on labor force behavior by age is presented in detail in Appendix B.

[2]See, for example, Smith (1971); Mincer (1971); and Cohen, Rea, and Lerman (1970). The last study most effectively illustrates this point.

[3]For women with less than a high-school education, and for non-white women, the evidence on this point is not clear.

men over their lifetime tend to be similar for those with college, high school, and elementary educations. The same is not true for white married women. Early in the life cycle, women in this category with college educations work more than women with either high school or elementary educations. However, during the child rearing years (between the ages of 25 and 40) the college educated women appear to reallocate more hours to household production than do the women with high school educations even though the former group has, on the average, fewer children than the latter. This pattern also holds for women with high school educations compared with those having only elementary educations. In fact, women with 8 or fewer years of schooling are the only group that shows no systematic reduction in hours worked during the peak child rearing years.[1]

One shortcoming of the above discussion is that the graphs underlying the relationships (see Appendix B) do not hold other factors constant. This is especially critical since similar labor force behavior patterns could be predicted from the income (full wealth) differences that wives with different educational levels can be expected to face.[2] Unfortunately, the several multivariate analyses of the labor force behavior of married women are not always in agreement with respect to the effect of children on the work activity of women by educational class. In Smith's (1972) regression work, the effect of the number of children under age 7 on hours spent in the home does not differ significantly for wives whose husbands have college, high school, and elementary educations, but two factors may be biasing these results. First, as indicated the regressions are not stratified by wife's education

---

[1]These observations are drawn from Smith's (1972) work (given in Appendix B) and hold only for white married women. Some caution must be used in interpreting these graphs, however, since the education levels used are those of the husband, not the wife. The figures still contain a good deal of information, because the correlation between spouses' education levels is very high.

Smith did extend his work to include black households, but there the pattern was significantly different. Black wives did not alter their allocation between market and non-market time during the child rearing years regardless of their education levels, giving them lifetime work patterns similar to those of white males.

[2]Glen Cain and a number of others have suggested that this may be the case.

but by that of her husband; second, the *spacing* of children has not been held constant between the education groups.[1] Since college women space their children closer together than women with less education, an equal amount of time per child withdrawn from work by both groups (college and less educated) could result in a larger *effective* amount of time being allocated to children by those with college educations if, as many argue, there are significant economies of scale in child rearing.

In a somewhat more meaningful test, Cohen, Rea, and Lerman (1970) include in their regressions on hours of work and labor force participation an interaction term that allows the effect of children to vary over educational classes. The results indicate that at least with respect to participation, college women stop working to a significantly greater extent than other educational groups when they have children. Leibowitz (1972) also finds evidence in several time budget studies to support the hypothesis that the higher a woman's education, the more time per child she allocates to child rearing when she does have children. Although the evidence is not conclusive, the direction seems to be toward upholding the observed gross differences in labor force behavior that Smith and Mincer find.

This behavior is open to several interpretations. It could be argued, for example, that highly educated women (or the households they reside in) desire high quality children, and that the differential labor force behavior of women by education class is indicative of the female time-intensity of child quality. This explanation has the prediction that, holding all other factors constant, increasing the wife's wage will reduce child quality more than numbers of children. An alternative interpretation of this behavior is given below based on the role of education as an efficiency factor.

To understand the nature of the efficiency parameters β and γ, it is useful to view the household, in its productive capacity, as one type of firm. As Grossman (1970) points out, real world firms are often observed having approximately equal physical inputs but widely

[1]The spacing argument was brought to my attention by James P. Smith.

divergent quantities of output. These differences are usually attributed to variations in entrepreneurial ability. It is reasonable to argue that a similar phenomenon takes place in household production; that is, households produce household commodities with varying levels of efficiency.[1] In the context of this model, the efficiency parameters are assumed to be strongly related to the education of the husband and the wife.

In many models of household production, changes in education are neutral in their effects on the marginal productivities of inputs. In this model, however, an increase in education is assumed to shift the marginal productivity of the inputs into Q more than it shifts the marginal products of inputs into C. Therefore, an increase in education, holding all other factors constant, makes Q more attractive than C when additional S is desired. If this is true, in households with high education levels, one would expect to observe a relatively large amount of the stock of S being held in the form of Q. Also, if women are involved to a greater extent than men in production of child services, the wife's education will be a more important efficiency factor in the production of S than the husband's.

The above propositions are offered as an alternative explanation for the differences by education levels in female labor force behavior discussed above (p. 13). This explanation is based on two assumptions, first that male time is relatively unimportant in production of child services and second that an increase in education brings about "own-factor augmenting" technical change.[2] Thus, holding wage rates constant, highly educated wives, even though they have fewer children, may withdraw from the labor force to a greater extent than less educated wives because their education has made them more efficient at producing child quality. Moreover, this increase in efficiency is not uniform over all

[1] The statement refers to the efficiency with which household A produces a given commodity relative to household B's production of that same commodity.

[2] For example, an increase in female education has a greater effect on the productivity of f male time than on other inputs. This assumption is not essential to the argument. See the entrepreneurial argument of footnote 1, p. 17.

inputs, but is especially concentrated in female time, leading highly educated women who work to reallocate large portions of their working time to production of child services.[1]

The use of education as a measure of household production efficiency does pose one rather severe problem. In an analysis of desired family size such as this one, parents are assumed to exercise some control over the number of children they have. Therefore, the determination of completed family size is not purely or primarily a function of biological considerations. The analysis does not rule out "mistakes," but it does assume that their distribution is random over households of varying wage, income, and education levels. If this is not true -- if, for example, education and contraceptive knowledge are highly correlated -- the estimated coefficient for either male or female education may contain price as well as efficiency effects.[2]

---

[1]One argument against this explanation is that women with low levels of education should be able to hire time of highly educated women as one input into child services, if such time is so productive. In one sense, this violates a very basic, although generally unstated, tenet of the household production model. To give household production models content one must separate inputs into "hired" (or purchased) inputs and home inputs (time of husband and wife). Hired time is assumed never to substitute perfectly for home (own) time. Although the underlying logic of this assumption has never been explored, its realism and usefulness are clear. Under this assumption, women with low education levels may not hire time of highly educated women simply because that time is a poor substitute for "own" highly educated time. Hiring the time of highly educated women for production of child services differs from purchasing other market goods and services in another important way. The efficiency factor discussed with respect to own time and education relates primarily to the woman's *entrepreneurial* capacity. Therefore, in this model, increasing female education does more than simply increase the effective amount of female time available to the household.

[2]See Michael (1970) for the formal derivation of this result. The problem arises only because the outputs of certain household production processes are not independent of the level of production of other household commodities. In this case, the argument is that adult time jointly produces both sexual pleasure and numbers of children. Thus, if the household is imperfectly contracepting, and sexual pleasure is just that, the shadow price of numbers of children will be reduced relative to the shadow price of child quality, other things equal.

The problem caused by differences in birth control knowledge arises in part because of the difficulty of establishing an adequate measure of this knowledge. Is it enough that the husband or wife knows that several birth control methods exist, or must they have tried some of these methods at one time or another? Also, does a lack of birth control indicate that parents are having more children than they would have had with additional birth control information or simply that they want more children?[1] The economics of information (Stigler, 1961) suggests that when making a decision, an individual will spend less on accumulating information the smaller the total resources involved. If child bodies are relatively cheap to one group of individuals, that group is expected to possess a lower level of birth control knowledge as well as to utilize that knowledge less. The problem is the old and frequent one of identifying cause and effect; to date, no adequate solution has been discovered.[2]

The interpretation of education as a measure of household efficiency precludes its use as a proxy for an individual's wage rate. This is primarily a problem for women in that at any one point in time a substantial proportion of married women in the United States are not working and thus have no observable market wage. The problem is not so severe for aggregate data. However, it does rule out the use of many bodies of household level data if one is interested in separating price of time and efficiency effects.[3]

---

[1]"Want" in an economic sense; that is, children are less expensive to those not using birth control methods.

[2]The problem may not be as serious as some might have us believe. As proof of this, Harman's study of fertility in the Philippines (Harman, 1970), where there are presumably much greater fluctuations in the level of birth control knowledge than in the United States, failed to discover any effect of differential birth control information or use on completed fertility.

[3]One possible method of overcoming this problem is through the use of instrumental-variables econometric techniques whereby the wife's wage is estimated from auxiliary data. Unfortunately, education is often the cornerstone of such calculations, given the well established link between schooling and earning potential.

CHILD RELATED FACTORS

Child Time

No mention has been made as yet of the effect of child time, or its value, on the household decisionmaking process. The formal model does not rule out producer durable aspects of children, but no systematic treatment of the effect of this characteristic has been given. However, this factor has been an important consideration in past models of desired family size and thus requires some discussion.

Variation in the value of child time has been often called upon as one explanation of urban-rural fertility differences. The gist of the argument is that farm children are a financial asset to their parents but city children are not; therefore, farm families will desire larger numbers of children than households in an urban environment, other things equal. Note that the emphasis is on the market (work) value of child time. As the household production model emphasizes, time can usually be productively employed *within* the household as well. One implication of the traditional argument, therefore, is that the elasticity of substitution between child time and "hired" time is larger than that between child time and adult home time. If this were not true parents who lived in urban areas could substitute the time of their children for their own time in the home, enabling them to allocate more hours to work.[1] Thus in household production models rural child time plays conceptually much the same role as urban child time in the household decisionmaking process, reducing the expected difference from this source.[2]

---

[1]The argument does not preclude the farm environment from having *any* effect on desired fertility, it simply reduces the expected magnitude of the effect. In fact, one would predict that the increase in the range of alternative uses for child time caused by the establishment of a family business such as farming would have a positive effect on desired fertility. But, unless the new alternative significantly increased the value of child time to the household, the expected magnitude of the effect would not be large.

[2]Large differences cannot be ruled out given the empirical nature of the issue. The purpose of the statement is to emphasize that the matter is one of degree, not of direction.

The farm setting may affect more than just the expected returns from child time. It may alter the price of both time and market goods and services inputs into children so as to lower the shadow price of child services relative to other household production-consumption. For example, living on a farm may reduce the cost of female time in household production even if the wife's market productivity level is unchanged. The reduction is brought about by the increased opportunity for joint production which a family operated business permits. In essence, a farm wife can work and participate in home production simultaneously, reducing the opportunity cost of female time in household production.[1] If this is true, then female time-intensive commodities, (S), will become more attractive to a farm household.

There are also price effects at work that may encourage farm families to substitute numbers of children for child quality *within* their production of child services. Goods inputs into the production of C, for example, basic food and shelter, are probably cheap in rural areas relative to purchased inputs into the production of Q, for example, schooling,[2] books, travel. Under these circumstances, farm families would find Q a costly means of increasing their stock of child services and would choose to hold relatively large proportions of that stock in the form of numbers of children.

Infant Mortality

The discussion so far has treated both C and Q as expected values and has ignored problems of uncertainty, poor forecasting, and the like. This exclusion requires elaboration at least of the effect of infant mortality on desired family size, since in the empirical formulation of the model the proxy for desired family size is not net of expected

---

[1] Glen Cain has pointed out that farm children may require less supervision, that is, are less time-intensive, than urban children and consequently are less costly from that standpoint also.

[2] The case for schooling seems clear from Finis Welch's work on quality of education (Welch, 1966). Welch found that rural areas were at a disadvantage compared with more densely populated areas in the production of "education" because rural schools were too small to take advantage of the apparently large economies of scale in education production.

infant losses. In order to correct for this, the usual procedure is to enter a measure of infant or child mortality as an independent variable in the regressions on desired numbers of children. Traditionally, the predicted sign for this variable has been positive based on the argument that in areas where infant mortality is high, parents must bear a relatively large number of children in order that a given number survive to adulthood. Note that in this theory the implicit assumption that leads to the predicted positive relationship is that, other things equal, all parents desire the same number of surviving children regardless of the infant mortality levels they expect. In order to justify this assumption, either the demand for surviving children must be perfectly inelastic, or the cost of an infant death must be zero. It is unlikely that either of these conditions hold; in fact, economic theory would lead us to argue that one of the factors on which parents base their "target" family size is the expected losses from infant deaths, or more accurately the costs associated with these losses. Thus whether an increase in infant mortality raises or lowers observed numbers of children ever born will depend in part on the costs associated with infant deaths (both pecuniary and psychic), and on the elasticity of demand for surviving children.

As O'Hara (1972) points out, there are other forces at work, specifically the substitution between Q and C in the household's production of child services, that may encourage parents to have large numbers of children, holding other things constant, in a regime of high infant mortality. The important distinction, however, is that these forces do not imply the strong "replacement" relationship that the traditional argument does.

SUMMARY AND PREDICTIONS OF THE MODEL

It will be useful at this point to summarize this discussion in terms of its implications for the model of Section II. A translation into symbolic notation yields the following nine expressions.

$$\alpha_{t_m} \overset{?}{\gtrless} \alpha_{t_f} \tag{11a}$$

$$\alpha_{t_{f,S}} > \alpha_{t_{m,S}} \tag{11b}$$

$$\alpha_{t_{f,C}} > \alpha_{t_{f,Q}} \tag{11c}$$ [1]

$$\mu_{S,\gamma} > \mu_{S,\beta} \tag{11d}$$

$$\mu_{Q,\gamma} > \mu_{C,\gamma} \tag{11e}$$

$$\frac{\pi_C^r}{\pi_Q^r} < \frac{\pi_C^u}{\pi_Q^u} \tag{11f}$$ [2]

$$\frac{\partial S}{\partial Pr} \overset{?}{\gtrless} 0 \tag{11g}$$

$$\frac{\partial C}{\partial Pr} \overset{?}{\gtrless} 0 \tag{11h}$$

$$\frac{\partial\ Q/C}{\partial\ Pr} > 0 \tag{11i}$$

where

α_{t_i} = share of ith household member in household commodity production.

$\alpha_{t_{i,j}}$ = share of ith household member in jth activity.

$\mu_{i,j}$ = partial elasticity of ith output with respect to the efficiency (education) of the jth household member.

π_i^r = marginal cost of ith factor in *rural* areas.

π_i^u = marginal cost of ith factor in *urban* areas.

Pr = probability of a child surviving to maturity.

The first three lines are concerned with the shares of male and female time in various activities. Lines d and e indicate the differential impact of male and female efficiency on certain production processes.

[1] This is more a function of the definitions of Q and C than of the discussion.

[2] For given levels of Q and C.

Line f describes the relationship between the relative prices of C and Q in urban and rural areas. The last three lines show the expected effects of changes in the probability of a child surviving on child services, numbers of children, and quality per child respectively.

Although the model and subsequent discussion result in few unambiguous predictions,[1] we are left with strong expectations on the signs of certain of the coefficients in Equations (9) and (10).

In Equation (9), female variables should "dominate" male variables. The effect of a change in female education or wage rates should be larger in absolute terms and contribute more to the explanatory power of the estimated equation than changes in male education or wages. Furthermore, since the female wage coefficient contains large negative substitution effects, and that for the male does not, the former should be arithmetically smaller than the latter. This is especially true if both S and C are female time-intensive, in which case the sign for the female wage coefficient should be negative.

Along similar lines, the sign of the female education coefficient should reflect the non-neutral efficiency effect of that variable on the production of C and Q, and thus should be arithmetically smaller than the male education coefficient. Again the female coefficient is likely to be negative if the differential efficiency effect is a significant factor.

Since the primary purpose of Equation (10) is a qualitative estimate of the relative shares of the inputs into C and Q, predictions are less apropos than for Equation (9). Nonetheless, the theory and discussion imply two propositions. First, if the effect of female education is predominantly on the production efficiency of Q, then $\mu_{Q,\gamma} - \mu_{C,\gamma}$ should be positive. Second, any measure of the household's full wealth (or non-wage-related income) should have no effect on the relative level of Q to C.

[1] In fact, in Equation (9), if (as is true) separate measure of the price of market goods and services inputs into Q and C are not available, the only remaining prediction is that an increase in non-wage related income should increase the demand for C.

If the model is a useful representation of household desired family size decisions, certain consistencies in the behavior of the variables should also be observed *between* the two equations. One has already been mentioned -- female education should have a negative coefficient in Equation (9) and a positive one in Equation (10). Another is that the coefficient for female wage rate should be arithmetically smaller in Equation (9) than in Equation (10), because of the female time-intensity of child services in general. A third is that the index of the price of market goods and services used in the estimations should exhibit consistent behavior in both equations. If, as is in fact the case, a measure of rurality is used to capture the relatively cheap goods and services inputs into C production in these areas, then the coefficient of that variable should be positive in Equation (9) and negative in Equation (10).

The most important implied consistency from the standpoint of testing the model, however, is that for the behavior of household full wealth in the two equations. As Equation (9) indicates, an increase in full wealth that is non-wage related should unambiguously increase the demand for numbers of children. In contrast, that same variable in Equation (10) should have neither positive nor negative effects on the dependent variable, since it is assumed to affect C and Q equally.

Although the empirical work of the following section cannot formally lead to a rejection of the model, it can contribute significantly to our "faith" (or lack thereof) in the underlying approach and thus is a legitimate exercise.

IV. AN EMPIRICAL FORMULATION OF THE MODEL

This section sets out the results of a preliminary empirical investigation of the model. Derived demand equations are estimated for numbers of children (Equation (9)) and quality per child (Equation (10)), using aggregate data drawn from a cross-section of U.S. counties.

THE DATA[1]

A sample of 555 counties was randomly selected from the approximately 3,300 counties of the continental United States; the primary source of the data is the U.S. Decennial Census of Population for 1960. Since these data are cross-sectional, they have a number of shortcomings. First, they fail to capture any aspect of the dynamic nature of the decisionmaking process. Second, for many of the women who make up the sample the relevant values of the variables are those 10 to 20 years prior to 1960.[2] Third, the theory yields equations whose form requires that the variables be expressed in percent changes, whereas the data are measures of levels. This transition does not affect the expected signs of the coefficients, however.[3]

THE VARIABLES[4]

The two dependent variables in the theoretical framework were numbers of children, C, and quality per child, Q/C. The variable for numbers of children has a relatively close empirical counterpart, children ever born to women of sufficient age to have completed

---

[1]A more detailed description of the data, including a list of the counties in the sample, is given in De Tray (1972).

[2]This problem may not be too severe given the time invariant nature of the variables used in the study.

[3]The fundamental assumption required to make this transition is that the parameters are constant over the entire range of the activity in question.

[4]A number of the problems concerning the variables are discussed in detail in Appendix C.

families.[1] For this analysis women 35 to 44 were chosen as the group with essentially completed fertility.[2]

Constructing an operational measure of child quality is a more difficult task. One approximate measure, in the sense the term is used in this study, is the expected full wealth of the child. The best available statistic summarizing a child's future economic prospects is the amount of education that child will receive. With the additional assumption that parents base their expectations on current conditions, quality per child is empirically estimated by the following formula:

$$\text{EXPED}_j = \sum_{i=1}^{n} \left(\frac{\text{ENR}_{i,j}}{\text{POP}_{i,j}}\right)\left(\frac{\text{EDEXP}_j}{\sum\limits_{i=1}^{N} \text{POP}_{i,j}}\right)$$

where

EXPED_j = expected public school investment per child in dollars for the jth county.

$\text{ENR}_{i,j}$ = number enrolled in school in the ith age group of the jth county.

$\text{POP}_{i,j}$ = population in the ith age group of the jth county.

EDEXP_j = total public educational expenditures by the jth county.

---

[1] One problem with this measure is that desired family size and completed family size may differ. The most often cited example of this is that poorly educated, low income households do not have sufficient birth control knowledge to limit their children to the desired number. Although it cannot be ruled out, the regression results offer little support for this view. See also footnote 2, p. 18 or Harman's (1970) work.

[2] This choice was governed by the fact that this is the oldest age group for which the Census gives figures for children ever born at the county level in 1960. One might argue, however, that some women in the group may plan to have additional children. If this were particularly true for women who postponed having children in order to participate in another time-intensive activity, attending college, then female education and children ever born would exhibit a spurious negative correlation. Fortunately, this does not appear to be true. See Appendix C for supporting evidence.

EXPED measures, in dollars, the amount of county public educational investment each child is expected to receive. The first term on the right hand side is the expected number of years of schooling per child. It is calculated under the assumption that each child of the ith age group who is enrolled in school receives one year of schooling for each year the age group spans. The second term is the expected county expenditure on education per child per year.[1]

In theory, enrollment and population for each year between, say, 5 and 19 is required to calculate this measure accurately. In practice, the years were grouped since the Census does not report enrollment by individual years.[2]

A point of clarification may be necessary here. In the theoretical model, child quality includes all investments in children, whereas the operational measure of that variable appears to capture only those investments that occur outside the home. The assumption implicit in the transition is that total child quality is highly positively correlated with expected public school investment at the county level.

There are obviously a number of shortcomings with this variable beyond those mentioned. The most serious involve the expenditure component. Its political nature will make it suspect for some; it contains both current expenditures and capital investments; it may be

[1]County educational expenditures are calculated from data in the 1962 City and County Data Book. The data are in the form of total county government expenditures and the percent of those expenditures classified as educational.

[2]The 1960 Census reported enrollment at the county level for the following age groups: 5 and 6, 7 to 13, 14 and 15, 16 and 17, 18 and 19. Population estimates were available in machine readable form only in five-year groups except for 14 year olds. The final formula for each county, therefore, took the following form:

$$EXPED = \left(9\left[\frac{ENR_{5-13}}{POP_{5-13}}\right] + 6\left[\frac{ENR_{14-19}}{POP_{14-19}}\right]\right)\left(\frac{EDEXP}{POP_{5-19}}\right)$$

where 9 and 6 are the maximum possible years of schooling for each age grouping.

a poor reflection of the quality of education being produced (Welch, 1966),[1] it fails to capture either private school or college investments in children, two areas where much of the variation in child quality may be occurring. To the extent that these criticisms are valid, they will tend to increase the error with which EXPED measures quality per child. If capital expenditures are randomly distributed among counties, their inclusion in the EXPED variable will reduce the explanatory power of the regressions and increase the standard errors associated with the estimated coefficients. The exclusion of private school and college inputs into the educational process will reduce the overall variation in EXPED and understate the amount of education received in "high quality" counties, biasing the estimated coefficients toward zero.

The independent variables are more straightforward.[2] The male and female efficiency parameters, β and γ, are measured by median years of schooling of adults 25 and over. Since wage rates by sex are not currently available at the county level, median earnings are used to measure these variables. Male earnings and male wage rates are sufficiently highly correlated, at both the aggregate and the household level, that earnings are a respectable proxy for the wage rate. The same, unfortunately, is not true for female earnings and wages. Smith's (1972) work points toward virtually no correlation between wages and earnings for individual women over their lifetime; however, at the highly aggregate state level, this correlation is almost as strong as that for men.[3] Even though the state sample should more closely approximate

---

[1] As mentioned earlier, Welch (1966) found that rural schools were often less efficient at producing education than their urban counterparts; thus, higher school expenditures in rural areas did not always mean higher educational output. Since the analysis attempts to remove this rural effect, the problem is somewhat mitigated here.

[2] One overall shortcoming, however, is that none of the independent variables is age-specific. See Appendix C.

[3] The simple correlation for the 48 contiguous states between male earnings and male wages is 0.91; that same correlation for women is 0.88. The wage figures were taken from Social Security full time (4 quarter) earnings data published in *Workers Under Social Security 1960*, Department of Health, Education and Welfare, Social Security Administration, Office of Research and Statistics, 1968.

the county sample than the individual data used by Smith, the lack of wage rates by sex is a serious shortcoming of the county data.[1]

Other income (V in the model) has traditionally been difficult to measure. The Census does not enumerate other income separately, but it does record median male and female earnings and median income. Unfortunately, since the base populations for these figures differ, it is not meaningful either to calculate other income by subtracting earnings from total income[2] or to enter all three measures in the same regression.

The proxy chosen for other income is the median value of housing in each county.[3] Housing expenditures and family size may, of course, be related in ways other than through the postulated wealth effect. For example it could be argued that households with large numbers of children will spend more on housing because they require more space, other things equal.[4] A positive partial correlation between numbers of children and housing value might therefore stem from this "scale" effect rather than from a positive wealth effect.

The available empirical evidence indicates that this is not the case. With respect to physical space, Reid (1962), in analyzing the effects of income on housing, points out that there is little variation in the number of rooms for a given household over its life cycle, although considerable variation in family size. Mueller (1970, p. 83), in analyzing household budget responses, also found that contrary to

---

[1]A second very serious problem with using earnings, and even wage rates, to measure the value of the wife's time in the market place was alluded to in the theoretical discussion of Section II. The level of wages a woman can command in the market place, and even more so, her market earnings, is not independent of the number of children she has or wants to have in the future. In other words, market earnings and numbers of children are not determined independently of each other, but simultaneously. See Nerlove and Schultz (1970).

[2]In fact, this procedure would lead to a negative average value for other income.

[3]Median value of housing and median income are highly correlated; the simple correlation between these variables for this sample is 0.82.

[4]Of course, "more space" and "larger housing expenditures" are not synonymous terms. In order to increase their physical living space, families may reduce the overall quality of their housing, thus keeping housing expenditures constant.

his own expectations, larger families do not pay more for shelter than smaller ones, other things equal. In a more direct test using the county data set, value of housing was regressed on median income, percent of the population urban, rural-farm and non-white, and number of children ever born. As would be predicted from Reid's work, income had a strong positive effect. In contrast to this, the inclusion of children ever born in the regression had no effect on housing value.[1] It will therefore be assumed that the coefficient of housing value measures the effect of changes in normal income on either numbers of children or quality per child and that the resulting coefficient is not a reflection of scale effects.[2]

The number of infant deaths per 1,000 live births is included in the regressions to account for exogenous variation in the expected survival rate of children.

The last three variables are measures of the general economic and social structure of each county: percent of the population living in urban areas, percent of the population that is rural, and percent of the population that is non-white. The first two are included in an attempt to account for cross-sectional variation in the price of market goods and services.[3] The last variable, percent non-white, is included to account for differences (if any) not captured by the other variables in the economic opportunities and constraints faced by non-whites.

Table 1 contains a description of the variables. Table 2 contains the summary statistics and Table 3 the weighted summary statistics. Table 4 is a simple correlation matrix for the variables. The "weighted"

---

[1]See Appendix C for these results.

[2]The Census does not record the median dollar value of housing if that value is less than $5,000. In the regressions, all counties for which this was true are given median housing values of $5,000, which will bias the estimated coefficients toward zero.

[3]Two measures of "ruralness" are used, one being percent of the population classified rural farm, and the other the percent of the employed population working in agriculture. Initial estimates contained only the rural farm measure. A problem of interpretation arose with this variable in that any increase in the percent of the population rural farm while holding percent of the population urban constant implies that the only remaining sector, percent rural nonfarm, must be decreasing.

Table 1

THE REGRESSION VARIABLES

Variable Name	Description
CEB35[a]	Children ever born per 1,000 married women 35 to 44 in 1960.
EXPED[a]	Expected public school investment per child in dollars (see text for formula), 1960.
EDM	Median years of schooling for men 25+, 1960.
EDF	Median years of schooling for women 25+, 1960.
MALEARN[a]	Median earnings in dollars of males who had earnings in 1959.
FEMEARN[a]	Median earnings in dollars of women who had earnings in 1959.
HSEVAL[a]	Median value of housing in dollars, 1960.
INFDTH	Infant deaths per 1,000 live births, 1960.
URBAN	Percent of the population living in towns of 2,500 inhabitants or more, 1960.
RURAL1	Percent of the population living on farms, 1960.
RURAL2	Percent of the employed labor force working in agriculture, 1960.
RACE	Percent of the population non-white, 1960.

[a]Variable entered in log form.

Table 2

SUMMARY STATISTICS

Variable	Mean	Standard Deviation	Minimum	Maximum
CEB35	3116.3	568.6	1962.0	5346.0
EXPED	2758.3	1180.0	323.0	8872.1
EDM	9.11	1.44	4.9	12.6
EDF	9.98	1.52	5.7	12.6
MALEARN	3366.1	1119.6	913.0	6546.0
FEMEARN	1575.0	517.4	442.0	3343.0
HSEVAL	8014.1	2882.9	5000.0	20200.0
INFDTH	27.5	11.4	0.0	72.5
URBAN	34.0	27.6	0.0	100.0
RURAL1	21.6	15.3	0.0	67.2
RURAL2	19.3	13.7	0.24	59.8
RACE	11.4	17.4	0.0	76.0

Table 3

WEIGHTED SUMMARY STATISTICS[a]

Variable	Mean	Standard Deviation	Minimum	Maximum
CEB35	2613.5	457.1	1962.0	5346.0
EXPED	3027.2	982.0	323.0	8872.1
EDM	10.3	1.34	4.9	12.6
EDF	10.8	1.22	5.7	12.6
MALEARN	4653.0	1093.8	913.0	6546.0
FEMEARN	2333.0	631.7	443.0	3343.0
HSEVAL	12953.0	4346.9	5000.0	20200.0
INFDTH	25.5	6.48	0.0	72.5
URBAN	71.8	28.0	0.0	100.0
RURAL1	6.81	11.19	0.0	67.2
RURAL2	6.37	9.68	0.0	59.8
RACE	11.3	11.7	0.0	76.0

[a]Each observation is weighted by the square root of the female population aged 35 to 44.

Table 4

SIMPLE CORRELATION MATRIX

Variable	EXPED	EDM	EDF	MALEARN	FEMEARN	HSEVAL	INFDTH	URBAN	RURAL1	RURAL2	RACE
CEB35	-.28	-.60	-.53	-.58	-.63	-.45	0.33	-.43	0.36	0.44	0.43
EXPED		0.43	0.55	0.48	0.25	0.25	-.29	0.07	-.06	-.001	-.41
EDM			0.91	0.81	0.58	0.71	-.37	.49	-.39	-.38	-.51
EDF				0.73	0.46	0.62	-.38	0.36	-.24	-.22	-.49
MALEARN					0.74	0.76	-.33	0.60	-.61	-.60	-.49
FEMEARN						0.64	-.27	0.49	-.50	-.61	-.43
HSEVAL							-.24	0.64	-.46	-.43	-.22
INFDTH								-.05	-.03	-.03	0.49
URBAN									-.61	-.55	-.09
RURAL1										0.92	0.05
RURAL2											0.09

means, standard deviations, and so on are based on the original sample weighted by the square root of the female population aged 35-44.[1]

THE RESULTS[2]

The results of the regression analysis are presented in Table 5. The variables do not all enter the regressions in the same form. As the model of Section II indicates, the two dependent variables, children ever born and expected schooling investment per child, as well as all measures of earnings and full wealth, are used in log form. Following Mincer's work,[3] years of schooling for both men and women enter as normal numbers, as do infant deaths and the three county characteristics measures, percent urban, rural, and non-white.

Numbers of Children (CEB35)

The results of the CEB35 regressions (Table 5, Regressions 1 and 2) are noteworthy for several reasons. First, in general, they confirm the results found by others (see, for example Gardner (1971) and Michael (1970)); second, they indicate that even when earnings are held constant, education levels of parents may have a separate and distinct effect on numbers of children; third, they provide evidence that numbers of children are, indeed, normal goods.

---

[1]The weighting factor, in all cases, is chosen so that the moment matrix will be weighted by the denominator of the dependent variable. The weighted statistics are included to show the degree to which the weighted sample accurately reflects the U.S. population. The reason for the difference between the weighted and unweighted figures is the random selection procedure used to choose the counties in the sample. No weighting factor was incorporated in this process; therefore, the unweighted sample has an inordinate number of small rural counties, which are reflected in the unweighted summary statistics. Since the other weighting factor -- population 5 to 19 -- gives much the same picture, only one set of weighted statistics is presented in the table.

[2]An analysis of the residuals of the two sets of regressions was undertaken also. The results indicate no particular underlying relationship between the CEB35 and the EXPED regressions. See Appendix E for a more detailed discussion.

[3]See for example, Mincer (1971), which summarizes much of his previous published and unpublished work and once again states the rationale for using years of schooling rather than the log of that number in equations explaining wage differences.

Table 5

THE REGRESSION RESULTS

Independent Variable:[a] (t-ratios) [elasticity at mean][b]	Dependent Variable			
	CEB35c		EXPED[c]	
	1[d]	2[d]	3[e]	4[e]
EDM: median years of of schooling, male	.0077 (.74)	.010 (.94)	-.068 (1.77)	-.044 (1.14)
EDF: median years of schooling, female	-.030 (3.19) [.32]	-.033 (3.45) [.36]	.092 (2.65) [.99]	.065 (1.82)
HSEVAL: median value of housing[c]	.065 (2.73) [.07]	.053 (2.18) [.05]	.073 (.81)	-.047 (.51)
MALEARN: median earnings, male[c]	.074 (2.12) [.07]	.086 (2.50) [.09]	.90 (6.96) [.9]	1.03 (3.13) [1.0]
FEMEARN: median earnings, female[c]	-.30 (12.5) [.30]	-.28 (11.2) [.28]	-.11 (1.23)	.053 (.57)
INFDTH: infant death rate	.0009 (1.24)	.0008 (1.11)	-.0048 (1.95) [.12]	-.0053 (2.16) [.14]
URBAN: percent urban	-.0022 (7.69) [.16]	-.0022 (7.94) [.16]	-.0001 (.09)	.0005 (.53)
RURAL1: percent rural farm	.0011 (1.74)	--	.0070 (3.04) [.05]	--
RURAL2: percent of employed labor force in agriculture	--	.020 (2.72) [.1]	--	.015 (5.78) [.96]
RACE: percent non-white	-.0005 (1.12)	-.0004 (.92)	-.0027 (1.67)	-.0018 (1.06)
CONSTANT	9.33 (41.1)	9.21 (39.9)	.347 (.41)	-.90 (1.04)
R^2	.75	.75	.47	.48
F	169	171	51.1	53.4
N	516	516	527	527

[a]For description of variables see Table 1.

[b]Absolute value. Given only for coefficients with t-ratios $\geq$ 1.95.

[c]Variable enters regressions in log form.

[d]Weighted by square root of female population 35 to 44.

[e]Weighted by square root of population 5 to 19.

The coefficients are remarkably strong, especially in view of the severe multicollinearity among some of the variables.[1] The statistically weakest coefficient is that for male education. This may be partly because of the close correlation of this variable with both female education and male earnings; it may also indicate that with earnings, full wealth, and female education held constant, changes in male education have little effect on numbers of children. The female education coefficient is strongly negative with an average elasticity of approximately -0.3. This relationship -- negative female education coefficient and insignificant or positive male education coefficient -- has often been observed in economic fertility data.[2] In the past it has been argued that education is a proxy for either price of time (female education) or permanent wealth (male education), or that education captures differences in contraceptive knowledge. With respect to the first of these, every effort has been made to remove wealth and time price effects. The continued existence of a strongly negative coefficient for female education and a very weak positive coefficient for male education indicates that these variables may have effects on numbers of children that are not associated with either wealth or relative prices. This result is consistent with the earlier contention that an increase in female education increases the efficiency with which child quality can be produced but has little effect on the production technology of numbers of children. This argument does not ensure a negative relationship between female education and CEB35, but it does suggest forces pushing the relationship in that direction. The behavior of the male education coefficient is too weak to draw a firm conclusion, but it may indicate that this variable is unimportant in determining desired numbers of children.

The education-contraception relationship is a difficult one to disprove. At this time I can argue only that if education were a

[1]The various tests for multicollinearity suggested in Farrar and Glauber (1967) were applied to the regressions. The worst problem occurred, as one might suspect, between male and female education. Several tests of the stability of the coefficients are given in Appendix D.

[2]See Gardner (1971), De Tray (1970), Michael (1970), and Ben-Porath (1970).

proxy for contraceptive knowledge, *both* male and female education should have negative partial correlations with CEB35. Proponents of the contraceptive knowledge interpretation might argue that the weak positive effect of male education results from multicollinearity. However, in the data I am familiar with, when the partial correlation between male education and numbers of children is significant, the sign of the coefficient is almost invariably positive.[1]

Increases in median value of housing have a small but significant positive effect on CEB35. In her housing-income study Reid (1962) found the pure income elasticity for housing expenditures to be around 2.0. If this latter measure is taken as correct, the HSEVAL coefficients imply on the average an income (full wealth) elasticity for numbers of children of 0.12.

Although the simple correlation between male and female earnings is quite high (0.73), the effects of these variables on CEB35 differ considerably. An increase in male earnings has a positive effect on children ever born, but an increase in female earnings has a strong negative effect. The associated elasticities for these two variables are male earnings, 0.09; female earnings, -0.30. These results are consistent with previous findings and the earlier discussion of these variables (see pp. 12-14). Numbers of children, as well as child services in general, have long been assumed to be female time-intensive; therefore, an increase in the price of female time causes the household to substitute away from both numbers of children and child services.[2] If the opposite is true for men, that is, that the share of male time in the production of both C and S is small relative to the share of that input into other household commodities (Z), then an increase in the price of male time will bring about a substitution toward both C and S.

---

[1]See also footnote 2, p. 18.

[2]Again, the reader must be cautioned about the simultaneous nature of the female earnings variable (see footnote 1, p. 29). The ordinary least squares regression technique used in this report is not capable of distinguishing the effect of earnings on desired children from that of children on female earnings. Therefore, this coefficient may contain a serious simultaneous bias.

The coefficient of the infant death rate variable is never significantly different from zero. In part this may be due to the offsetting effects associated with this variable discussed earlier (see pp. 20-21).[1]

URBAN and RURAL behave as predicted under the assumption that they measure variations in the price of market goods and services. An increase in percent urban lowers the desired number of children, but a similar change in percent rural increases the desired number of children.

In the past, demographers and sociologists have implied that non-whites produce more children than whites, other things equal. The coefficient for RACE contradicts this belief. If education levels, earnings, and so on are held constant, increasing the percent non-white in a county has, if anything, a weak negative effect on children ever born.

Table 6 illustrates the reasonable magnitude of effects on the predicted number of children ever born associated with plausible changes in certain variables.[2] If these estimates are valid, zero population growth is, so to speak, just around the corner since the postulated changes in the variables indicate a reduction in predicted family size from 2.6 children per woman to 2.3 over a ten-year period.

Quality per Child (EXPED)[3]

The regressions on EXPED (Table 5, Regressions 3 and 4), are less statistically significant than those on CEB35. This is not unexpected given the crudeness of the measure of quality per child.

The variables EDM and RURAL exhibit what appears to be anomalous behavior. The male education coefficient is insignificant or negative,

[1]It may also reflect the fact that the expected infant mortality rates on which women 40 years old in 1960 based their fertility decisions were those of 1940 or so, and not those of 1960.

[2]The choice of the "plausible changes" was not entirely arbitrary. In each case, the 1960 values for the variables were increased or decreased by the percent change for comparable variables between 1950 and 1960; thus, the "prediction" is for decennial, not annual, changes in the variables. Note that only those variables with statistically significant coefficients were changed.

[3]Again, see Appendix D for tests of the stability of the coefficients.

Table 6

PREDICTED DECENNIAL CHANGE IN CHILDREN EVER BORN
PER WOMEN 35 TO 44
(percent)

Initial predicted value (1960)	2.64 Children ever born
Changes in exogenous variables[a]	
Female education	+14%
House value (full wealth)	+39%[b]
Male earnings	+43%[b]
Female earnings	+42%[b]
Percent of population urban	+12%
Percent of population rural-farm	-55%
New predicted value	2.34 Children ever born
Change in children ever born	-11.5%

[a]Based on 1950 to 1960 changes for comparable variables.

[b]Represent *real* not nominal changes.

implying that either (1) the effects of male education are approximately the same for both numbers of children and for child quality, or (2) if anything, male education contributes more to the production efficiency of numbers of children than to the efficiency with which child quality is produced. This last explanation seems unlikely on grounds of common sense.

It was argued during the discussion of the CEB35 results that the purpose of URBAN and RURAL was to remove cross-sectional variations in the price of market goods and services from the regressions. Implicit in this statement is the presumption that in rural counties, market goods and services that are primary inputs into numbers of children will be cheap relative to goods and services entering child quality production. This, in turn, implies that the coefficient for RURAL in the EXPED regressions should be negative; in fact, this coefficient is strongly positive.

Part of the solution of this puzzle may be found in Welch's (1966) work on quality in education, where he observes that educational expenditures are, in and of themselves, poor indicators of the quality of education being produced by schools. He attributes this to the existence of "economies of scale" in the educational process. In essence, his argument is that schools in sparsely populated areas suffer because their facilities fall well below the optimal size.[1] If this is true, rural areas are likely to receive less education per dollar expenditure than more densely populated urban areas.

These scale effects will at minimum cause EXPED to overestimate quality per child in rural areas. The positive coefficient for RURAL is a result of this latter phenomenon plus the fact that education, earnings, and income are being held constant. In other words, if the rural population has tastes similar to the urban population for quality per child as measured by EXPED, then, with prices and income held constant, rural counties are likely to have relatively high educational expenditures per eligible population to partly offset the inefficiencies

[1]Also, Welch points out that a significant fraction of rural educational expenditures went for transportation, which, again, implies that rural school dollars "buy" less education than urban school dollars.

of their school systems. One problem with this explanation is that the interpretation of RURAL in the CEB35 regressions must now be reconsidered. The argument for a positive partial correlation between CEB35 and RURAL now hinges on the net effect on the price of *child services* of both positive (cheaper goods inputs into C) and negative (more expensive schooling input into Q) forces. Clearly the relative levels of Q and C in rural areas should shift unambiguously in favor of C. This, however, does not imply that rural communities consume more child services, other things equal, since the effect of rural areas on the price of that household commodity is ambiguous.

Female education has a strong positive sign as would be expected from the earlier efficiency arguments (pp. 16-17), and the partial correlation of female education in the children-ever-born regressions. Since quality does not appear to be particularly female time-intensive compared with numbers of children (the coefficient for female earnings is not significant in either EXPED regression) this finding lends support to the "efficiency" (as opposed to time intensity) explanation of the observed differences by educational class in female labor force participation (see pp. 14-17). The implication of this result is that female education increases the efficiency with which child quality is produced more than it increases the efficiency with which numbers of children are produced.

It is tempting to interpret the insignificant coefficients for HSEVAL as indicating that the derived income elasticities for Q (total quality in children) and for C (numbers of children) are equal in size.[1] This interpretation supports the quantity-quality substitution hypothesis and the particular functional forms chosen for the model. Indeed, it is surprising that EXPED and HSEVAL are not positively related if for no other reason than that school expenditures are usually derived from property taxes. However, it is always difficult to attach precise meaning to insignificant coefficients; therefore, this finding must be viewed with considerable caution.

[1]That is, EXPED is a proxy for Q/C (the relative amount of Q to C), which is invariant with respect to scale (non-wage income) effects.

As in the CEB35 regressions, male and female earnings have very different effects on quality per child. The strength and size of the positive male earnings coefficient make its theoretical interpretation suspect. According to theory, male time would appear to be used more heavily in quantity rather than quality production.

The strong negative coefficient for infant death rates is consistent with the theory that the higher the probability of a child's dying the less likely parents are to invest large amounts of resources in that child (see O'Hara, 1971). The statistical strength of this coefficient may also be a function of the fact that the rate at which infants survive is not, as has been traditionally assumed, always exogenous to household decisions. The more resources invested in each child, the more likely that child is to survive. But, the more resources a household invests in children, the higher the quality of those children. Thus infant mortality and expected school expenditures may both be a measure of child quality; it is not surprising, therefore, that they are strongly related.

SUMMARY OF EMPIRICAL RESULTS

This empirical analysis explores the derived demand for both numbers of children and quality per child. In general the estimated equations are quite satisfactory in that the coefficients are usually consistent with the implications of the model and the proportions of the variation explained by the independent variables are respectable.

Both sets of regressions (CEB35 and EXPED) imply that production of child services is dominated by women. The role of men seems primarily as suppliers of market goods and services, but this part of the picture is still unclear.

Female earnings are the single most important determinant of completed family size in terms of both magnitude of effect and statistical significance.[1] Other variables having a significant negative effect on children ever born are female education and the degree to which a county is urban. On the other hand median value of housing

---

[1]See footnote 2, p. 37 on the possible bias in this result.

and male earnings both exert a positive influence on desired numbers of children. In addition, the children-ever-born regressions indicate that (1) the full wealth elasticity for numbers of children is probably positive, but small, and (2) when economic differences are accounted for, race plays virtually no role in determining family size.

The regressions on quality per child are weaker than those for numbers of children. In part, this must stem from the proxy variable used in the regressions (expected county public school investment) which undoubtedly contains large errors of measurement. The principal findings from these regressions are, first, that female education increases the relative efficiency with which child quality is produced, thereby reducing its effective real price; and second, that the derived income elasticities for numbers of children and for child quality appear to be equal. Also, although it is not a prediction of the theory, the behavior of the rural and race measures indicate that there is little difference in "tastes" for child quality between either rural and urban residents or whites and non-whites, other things equal.

Appendix A

DERIVATION OF THE MODEL[1]

Let the household utility function be represented by

$$U = U(S,Z), \qquad \text{(A-1)}$$

where S is child services, and Z is everything else. Production functions for S and Z are assumed to be linear homogeneous, with average costs of π_S and π_Z respectively. The household budget constraint may then be written as

$$R = \pi_Z \cdot Z + \pi_S \cdot S \qquad \text{(A-2)}$$

where R is a measure of the household's full wealth. Under the assumptions of linear homogeneity, changes in the demand for S can be written

$$ES = \eta ER - [k\eta + (1 - k)\sigma]E\pi_S + (1 - k)(\sigma - \eta)E\pi_Z \qquad \text{(A-3)}$$

where the "E" operator denotes percent change (for example, ES = d(log S) = (1/S)dS), η is the income (wealth) elasticity of the demand for S, σ is the elasticity of substitution between S and Z in U(S,Z), and k is the share of full wealth spent on S $(=(\pi_S \cdot S)/R)$.

The production function for S takes the following form:

$$S = S(Q,C) \qquad \text{(A-4)}$$

where Q = child quality input and C = child body input. Since Equation (A-4) is linear homogeneous,

$$E\pi_S = \alpha E\pi_C + (1 - \alpha)E\pi_Q \qquad \text{(A-5)}$$

[1]Professor H. Gregg Lewis first put me on this particular tack and supplied an outline of the derivation.

where π_Q = per unit "rent" of the stock of quality, Q; π_C = per unit "rent" of the stock of child bodies, C; and $\alpha = \pi_C \cdot C/\pi_S \cdot S$.

From the definition of the elasticity of substitution between two factors of production and from the fact that in equilibrium, $(\pi_C)/(\pi_Q) = MP_C/MP_Q$ (the ratio of the prices of C and Q must equal the ratio of their respective marginal products in the production of S),

$$ES - EC = \sigma^* (E\pi_C - E\pi_S) \qquad \text{(A-6)}$$

where σ^* = elasticity of substitution between C and Q in the production of S. Therefore, from (A-3), (A-5), and (A-6),

$$\begin{aligned} EC = \eta ER - \{\alpha[k\eta + (1 - k)\sigma] + (1 - \alpha)\sigma^*\}E\pi_C \\ + (1 - \alpha)[\sigma^* - k\eta - (1 - k)\sigma]E\pi_Q \\ + (1 - k)(\sigma - \eta)E\pi_Z \ . \end{aligned} \qquad \text{(A-7)}$$

Full wealth is defined as

$$R = V + W_m + W_f \qquad \text{(A-8)}$$

where V = property wealth; W_f = lifetime possible wage earnings of the female, and W_m = lifetime possible wage earnings of the male. From Equation (A-8),

$$ER = \frac{V}{R} EV + \frac{W_f}{R} EW_f + \frac{W_m}{R} EW_m \ . \qquad \text{(A-9)}$$

Again, the E operator signifies percent change.

As with S, the production functions for C, Q, and Z are linear homogeneous; each takes as inputs three factors. That is,

$$Q = Q(t_{m,Q}, t_{f,Q}, x_Q; \beta, \gamma)$$

$$C = C(t_{m,C}, t_{f,C}, x_C; \beta, \gamma)$$

$$Z = Z(t_{m,Z}, t_{f,Z}, x_Z; \beta, \gamma) \qquad \text{(A-10)}$$

where $t_{m,C}$, $t_{m,Q}$, and $t_{m,Z}$ are time of male in the production of C, Q, and Z respectively; $t_{f,C}$, $t_{f,Q}$, and $t_{f,Z}$ are market goods inputs into the production of C, Q, and Z. The environmental variables β and γ represent the husband's and the wife's quality respectively and are a function of the amount of formal schooling each has received. The male's time has a price of w_m, the female's time a price of w_f, and the market goods have prices of p_C, p_Q and p_Z respectively. From these equations it follows that

$$\left.\begin{aligned}
E\pi_C &= \alpha_{t_{m,C}} Ew_m + \alpha_{t_{f,C}} Ew_f + \alpha_{x_C} Ep_C - \mu_{C,\beta} E\beta - \mu_{C,\gamma} E\gamma \\
E\pi_Q &= \alpha_{t_{m,Q}} Ew_m + \alpha_{t_{f,Q}} Ew_f + \alpha_{x_Q} Ep_Q - \mu_{Q,\beta} E\beta - \mu_{Q,\gamma} E\gamma \\
E\pi_Z &= \alpha_{t_{m,Z}} Ew_m + \alpha_{t_{f,Z}} Ew_f + \alpha_{x_Z} Ep_Z - \mu_{Z,\beta} E\beta - \mu_{Z,\gamma} E\gamma
\end{aligned}\right\} \qquad \text{(A-11)}$$

where $\alpha_{t_{m,C}} = (t_{m,C} \cdot w_m)/\pi_C \cdot C)$ and the other αs are similarly defined, $\mu_{C,\beta}$ is the partial elasticity of C with respect to β, with similar definitions for the other μs.

Now, combining (A-9) and (A-11) with (A-7), the following expression for the percent change in C is obtained.

$$\begin{aligned}
EC = {} & (V/R)\eta EV \\
& - \alpha_{x_C} \{\alpha[k\eta + (1-k)\sigma] + (1-\alpha)\sigma^*\} Ep_C \\
& + \alpha_{x_Q} (1-\alpha)[\sigma^* - k\eta - (1-k)\sigma] Fp_Q \\
& + \alpha_{x_Z} (1-k)(\sigma - \eta) Ep_Z \\
& + \{(1-\alpha)\sigma^*(\alpha_{t_{m,Q}} - \alpha_{t_{m,C}}) + (1-k)\sigma(\alpha_{t_{m,Z}} - \alpha_{t_{m,S}}) + (e_m/R)\eta\} Ew_m \\
& + \{(1-\alpha)\sigma^*(\alpha_{t_{f,Q}} - \alpha_{t_{f,C}}) + (1-k)\sigma(\alpha_{t_{f,Z}} - \alpha_{t_{f,S}}) + (e_f/R)\eta\} Ew_f
\end{aligned}$$

$$+ \{(1-\alpha)\sigma^*(\mu_{C,\beta}-\mu_{Q,\beta}) + (1-k)\sigma(\mu_{S,\beta}-\mu_{Z,\beta}) + \eta[k\mu_{S,\beta}+(1-k)\mu_{Z,\beta}]\}E\beta$$

$$+ \{(1-\alpha)\sigma^*(\mu_{C,\gamma}-\mu_{Q,\gamma}) + (1-k)\sigma(\mu_{S,\gamma}-\mu_{Z,\gamma}) + \eta[k\mu_{S,\gamma}+(1-k)\mu_{Z,\gamma}]\}E\gamma \quad \text{(A-12)}$$

In order to ease the reader's task, non-mnemonic symbols all will be defined here.

E = d(log) operator (percent change).

V = non-wage related income.

R = full wealth.

η = income elasticity of S, child services.

α = the share of expenditures on C in total expenditures on S, that is, $(\pi_C \cdot C)/\pi_S \cdot S$.

σ^* = the elasticity of substitution between C and Q in the production of S.

$\alpha_{i,j}$ = the share of expenditures on the ith input in total expenditures on the jth output, where $i = x, t_m, t_f$, and j = C, Q, Z, S.

k = the share of total expenditures on S in full wealth, R.

σ = substitution elasticity between S and Z in U(S,Z).

p_i = price of market goods and services x_i.

e_i = lifetime market earnings of the ith household member, $i = m,f$.

w_i = wage rate of ith household member.

$\mu_{i,j}$ = the partial elasticity of the ith output with respect to the educational levels of the jth household member, i = C, Q, S, Z and $j = \beta, \gamma$.

Appendix B

THE LABOR FORCE BEHAVIOR OF WOMEN BY EDUCATIONAL CLASSES

Figures B-1 through B-4 are taken from the ongoing research of Smith (1972) and Mincer (1970). They are presented here in support of the argument that highly educated women may withdraw proportionally more of their time from work during child rearing years than do women with relatively low levels of education. Smith's graphs are based on data derived from the Survey of Economic Opportunity (SEO) sample from 1967, and Mincer's information is drawn from the U.S. Census 1 in 1,000 data.[1] Note that every measure of work or home activity shows college women spending more time in the market place than any other educational class during the early years of their working lives. The situation is almost invariably reversed as one proceeds through the child bearing and child rearing ages.

These observations represent gross effects rather than the desired partial relationships. Since income of spouse is not held constant in the data used to plot the graphs, it is likely that some of the observed labor force behavior may be due to household income differences. In fact, Smith's (1972) work in this area indicates that under more sensitive multivariate analysis these differences across educational classes do not hold up for his data. However, in their study of time allocation, Cohen, Rea, and Lerman (1970) conclude that more educated women do withdraw from work more than less educated women when children are present in the house. Also, as indicated in the text, Liebowitz (1972) concludes from her study of both Census data and household budget evidence that the time input per child is higher the higher the education level of the mother. The evidence is thus somewhat inconclusive, but the scales seem to be tipping in

[1]As the titles of the graphs indicate, the education and age used in Smith's work are those of the husband. However, since the figures used are averages over age groups, the correlations between the education and the age of husbands and wives are very high. On the average, wives are somewhat younger than their husbands.

favor of upholding the hypothesis that highly educated mothers allocate relatively more time to children than do mothers with less education.

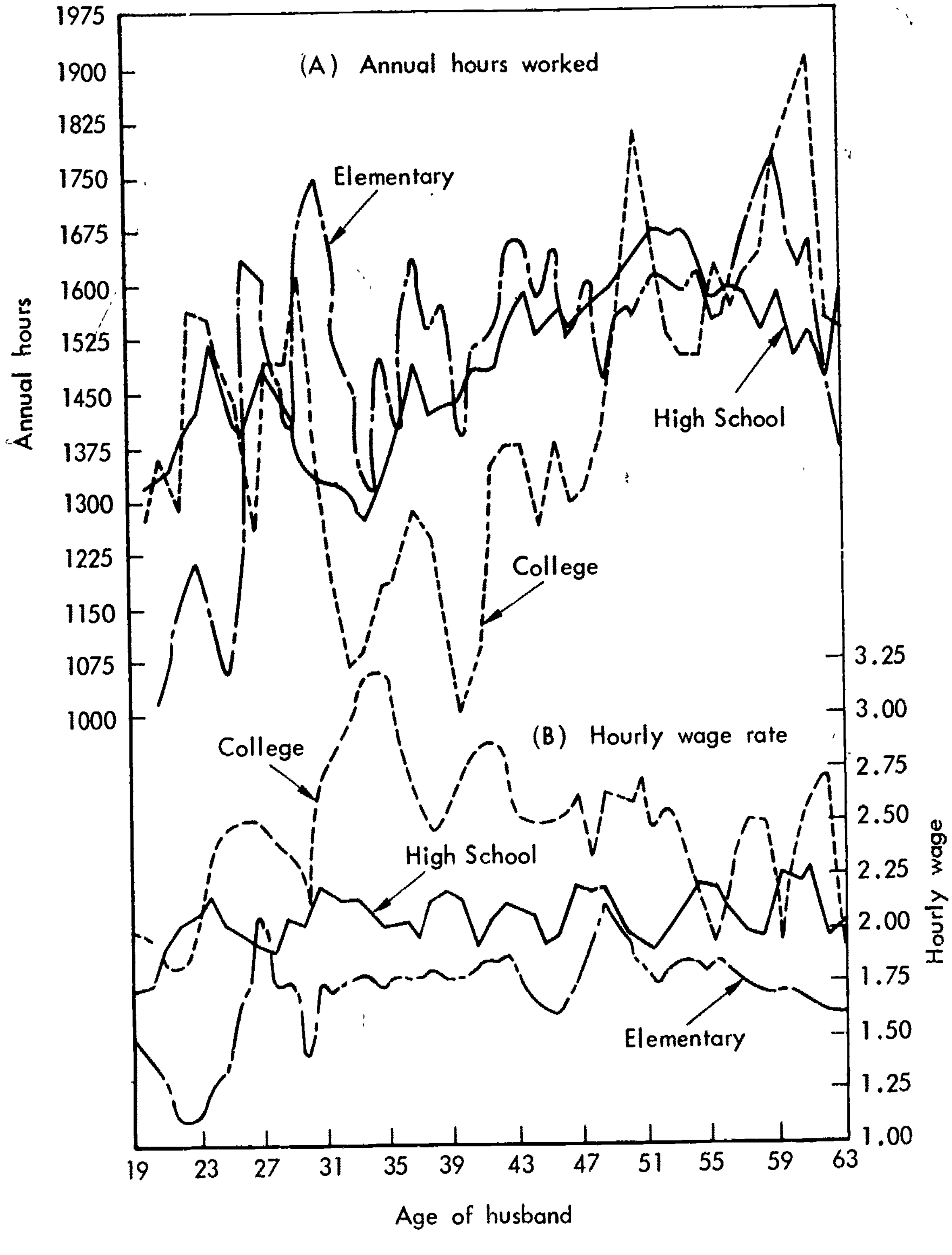

Fig. B-1 — Annual hours worked and hourly wage rate, all white working females by education of husband

Source: Smith (1971)

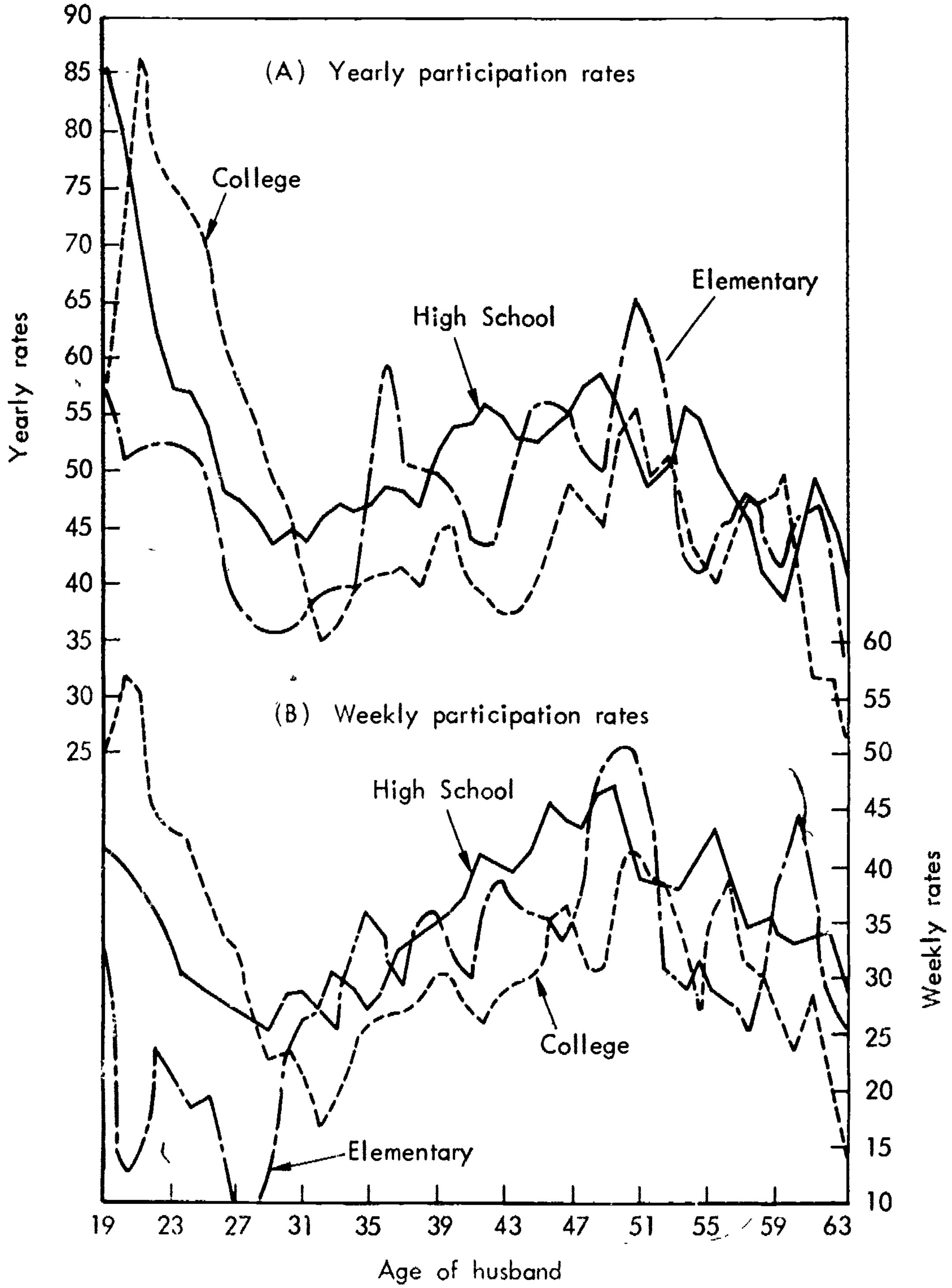

Fig. B-2 — Yearly and weekly participation rates, all white married females by education of husband

Source: Smith (1971)

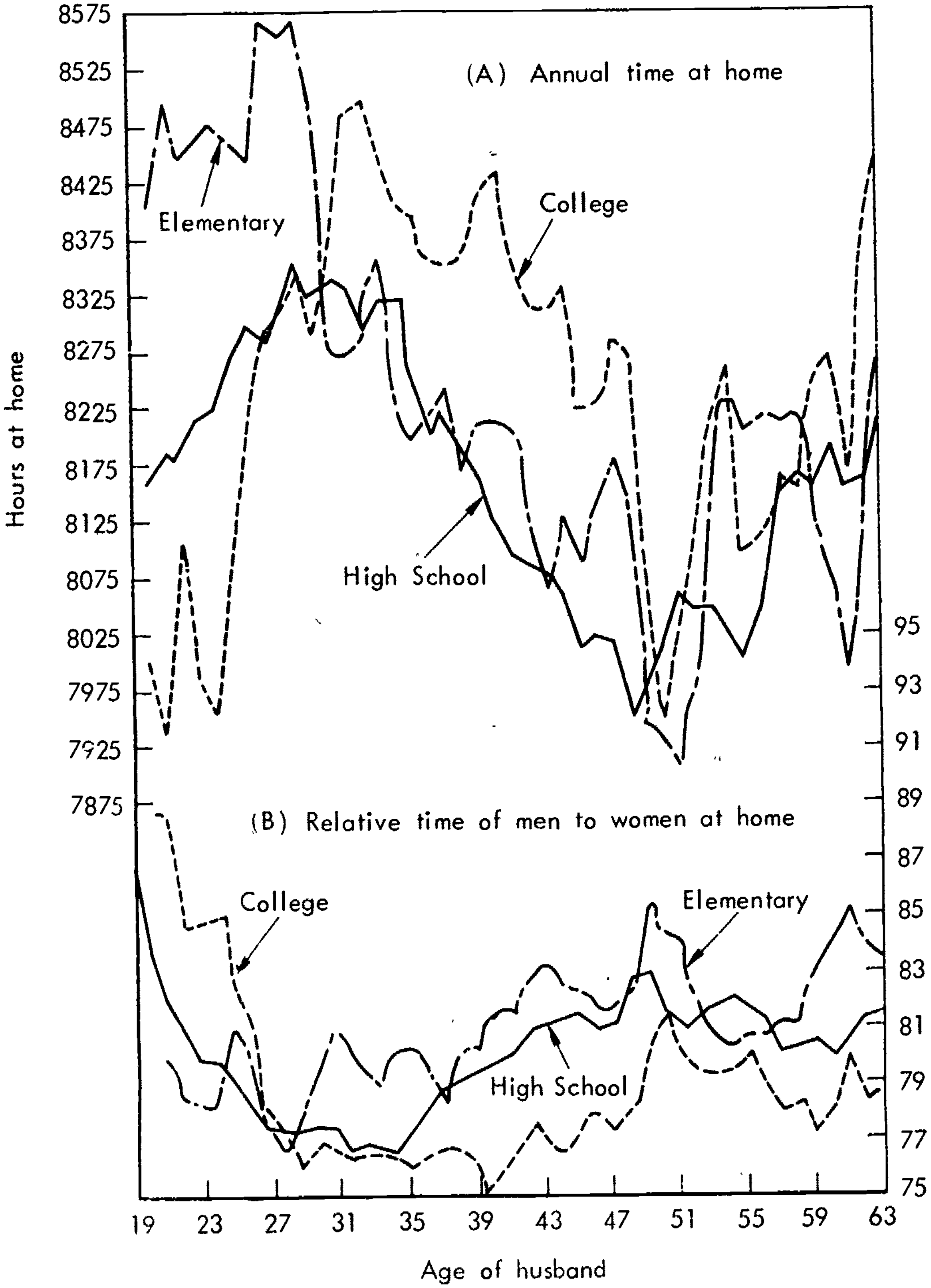

Fig. B-3 — Annual time at home and relative time of men to women at home, all white married females by education of husband

Source. Smith (1971)

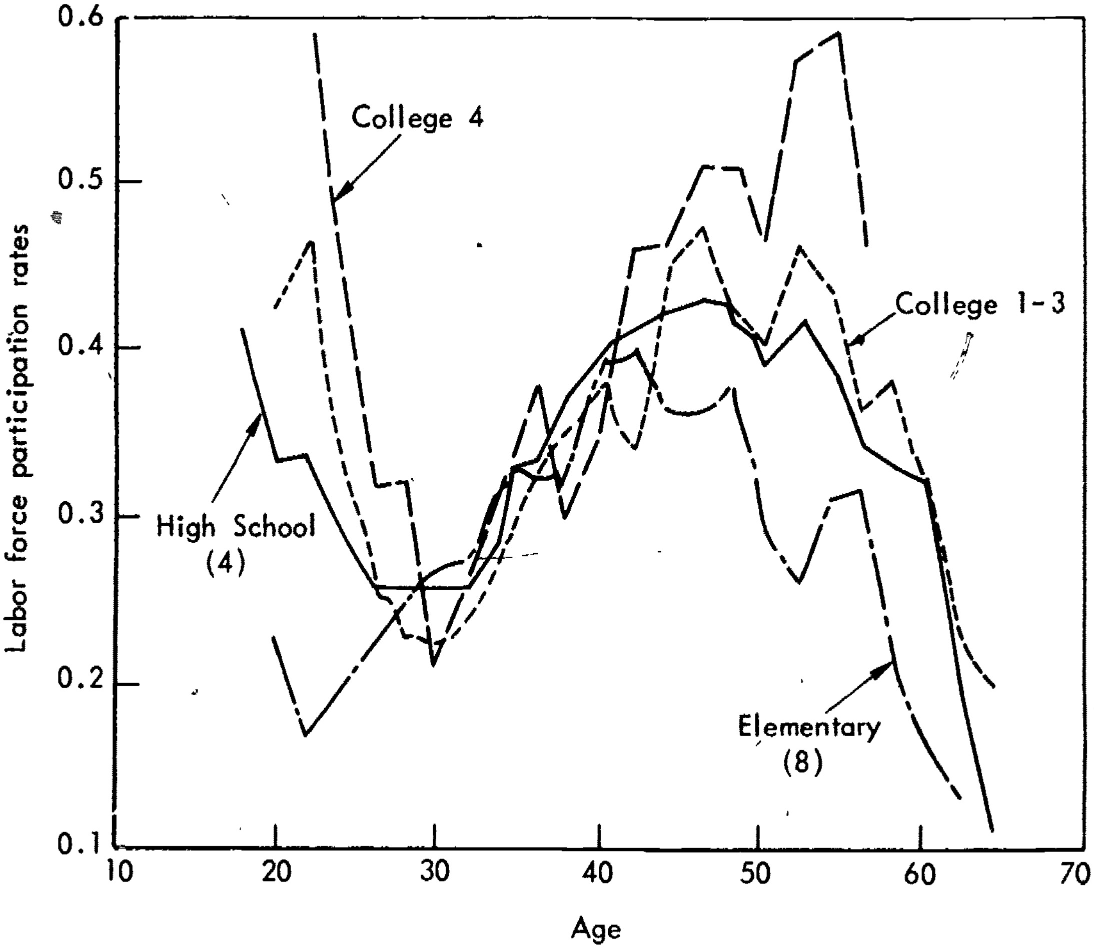

Fig. B-4 — Education and labor force status of women

Source: Mincer (1971)

Appendix C

THE VARIABLES: DETAILED DISCUSSION AND SUPPORTING EVIDENCE

AGE RELATED BIASES

One shortcoming of the independent variables is that, unlike children ever born and school investment, they are not age-specific. Therefore, variations in the age structure of each county may affect, for example, measured median years of schooling for the county in ways unrelated to years of schooling of women or men in a specific age group. Initially it was thought that age related variations could be removed from the data by the following method. With respect to education, since the county age structures are known, an expected level of years of schooling could be calculated using the U.S. age-education profile. The deviation of this latter estimate from actual measured years of schooling is in part a function of the difference between the county's own age structure and that of the United States. However, this difference will also depend on differences in the "true" (non-age-related) levels of education in each county. Thus, the system is unidentified in the sense that the deviation between actual and measured years of schooling can arbitrarily be separated only into "age" and "true" components. Which of these two possibilities -- predicted or median schooling -- is the better measure of male and female schooling for the population 35 to 44 is open to question. For the regressions, median education was chosen.

The problems raised by differences in county age structures are not always as severe as this comment suggests. The biases introduced into the regression, in some cases, may be toward zero. One variable for which this is true is female education. The secular increase in education over time implies that in counties with relatively old age structures, median years of schooling of females 25 years of age and over will underestimate years of schooling for women 35-44. One reason why some counties have old age structures, however, may be that, both now and in the past, they had relatively low levels of children ever born.[1] Thus counties that exhibit relatively low completed years of schooling because of an old age structure may also have relatively small numbers of children ever born. The converse is true for counties with young age structures. Therefore, differences in age structure among counties can, in and of themselves, produce a positive relationship between female education and children ever born. If this relationship is found to be negative as has been the case elsewhere, the coefficient may be an underestimate of the true relationship. The opposite would be true if education and children ever born were positively related, as has occasionally been the case for male education.

With respect to male and female earnings, a problem arises not via secular trends but through variations in these variables over the life cycle. In general, earnings have been observed to rise over the entire working life time of an individual, but at a steadily diminishing rate.[2] Therefore, in counties with particularly young age structures, median earnings will understate the earnings of individuals 35 to 44; the opposite will hold for counties with especially old populations. The effective biases, if any, will therefore be similar to those discussed for education. If the predicted relationship between numbers of children and earnings is negative, then the estimated coefficient may be an underestimate of the true effect, and a positive coefficient may be an overestimate.

How systematically strong any of these age related effects are is certainly open to question; however, their existence, plus the effect of migration on the sample, must surely contribute to the unexplained variation in the regressions and to the standard errors of the individual coefficients.

---

[1] That is, one factor contributing to an old age structure over time is fewer young children.

[2] This is more characteristic of male earnings profiles than those for females; women, on the average, have relatively flat age-earnings profiles, which reduces the expected impact of the effects discussed here.

HIGHER EDUCATION AND THE POSTPONEMENT OF CHILDREN: THE EVIDENCE

One potential shortcoming of the children-ever-born measure, as mentioned in the text, is that some women in this age group, especially those aged 35-39, may plan to have additional children in the future. This may be particularly true for women who postponed having children to participate in other time-intensive activities, especially attending college. If this is the case, the partial relationship between female education and numbers of children would be biased in a negative direction. Fortunately the effect of this bias, if it exists at all, appears to be very small, as is illustrated by Table C-1. The data presented in the table were taken from a study by Sutton and Wunderlich (1967) on fertility rates by age and educational attainment. Note that college women do the majority of their "catching up" shortly after leaving college. Thus, by ages 35 to 39, birth rate differences by educational class are minimal.

HOUSING VALUE AND FAMILY SIZE -- THE SCALE EFFECT

Table C-2 presents regressions that partially refute the hypothesis that median value of housing and numbers of children may be positively related through a "scale" effect whereby large families spend more on housing because they require more space. The results indicate that counties with large numbers of children ever born do not exhibit higher than average median housing values.

Table C-1

LEGITIMATE BIRTHS PER 1,000 MARRIED WOMEN, HUSBAND PRESENT, BY AGE AND YEARS OF SCHOOLING

		High School		College	
Age of Women	Elementary School 8 Years or Less	1-3 Years	4 Years	1-3 Years	4+ Years
15 to 19	529	588	449	a	a
20 to 24	319	322	324	432	456
25 to 29	321	205	200	222	243
30 to 34	162	112	97	169	155
35 to 39	74	57	49	67	80
40 to 44	22	14	17	12	6

Source: Sutton and Wunderlich (1967), p. 141.

[a]Omitted because of excessive sampling variation.

Table C-2

HOUSING VALUE REGRESSIONS[a]

Independent Variable[b]	1	2
INCOME: Median family income	1.04[c] (24.4)	1.02[c] (24.2)
CEB35: children ever born to women 35 to 44	-.082 (1.1)	-.027 (.38)
URBAN: Percent population living in urban areas	0.0047 (10.5)	.0052 (11.0)
RURAL1: Percent population rural-farm	.091 (8.0)	--
RURAL2: Percent labor force in agriculture	--	.0078 (7.78)
RACE: Percent population non-white	.0056 (7.97)	.0057 (8.01)
INTERCEPT	.63 (.73)	.26 (.36)
R^2	.85	.85
F	599	594
N	516	516

[a]The regressions are based on the county data set. Regressions are weighted by the number of housing units in each county.

[b]Definitions of variables are given in Table 1 of text.

[c]The difference between the income elasticity for housing that these regressions imply (around 1.0) and those of Reid (1960) (around 2.0) are predictable. In fact, before Reid adjusted for a number of other factors (age composition, for example), her elasticities were in the 1.0 range also.

Appendix D

STABILITY OF THE COEFFICIENTS

As mentioned in Section IV, the Farrar and Glauber (1967) tests indicated that even at the relatively disaggregate county level, multicollinearity exists among the independent variables. To increase the confidence with which the regression results could be viewed, I performed certain tests on the stability of the coefficients. None of these tests resulted in any significant change in the size of either the coefficients or the associated t-ratios.

The results of these tests will not be reported in detail, but the tests themselves are outlined below:

1. Whenever regressions are weighted, and the weights involved vary considerably, there is always a danger of a very large outlier completely dominating the coefficient calculations. This presents no problem unless the outlier is not from the same "population" as the other observations. To ensure that this was not the case, upper bounds were placed on both the CEB35 and the EXPED weights. Both weights were bounded within three standard deviations of the mean, so that only the very largest outliers were excluded.
2. Severe multicollinearity can lead to large changes in coefficients whenever the sample over which the regressions are run is changed. To test for this, the sample was arbitrarily reduced from around 525 to 300.
3. The behavior of the proportion rural measure and of the male education measure initially cast some doubt on the EXPED measure. Also, some counties had unreasonably high or low educational expenditures per eligible population. To test that it was not simply the range of educational expenditures that was responsible for the EXPED results, educational expenditures were bounded both above and below. The range for the whole sample for educational expenditures per population 5 to 19 was 31 to 744; the restricted range was 100 to 400.

Appendix E

AN EMPIRICAL ADDENDUM: MARRIAGE AND RESIDUALS

During the final stages of the empirical work discussed in Section IV, several avenues of interest not directly related to the theory of Section II were explored. One such topic is the relationship between marriage and desired family size. Several recent studies on the economics of marriage[1] have put forward the argument that the demand for marriage can be viewed as a "derived demand" stemming from people's desire for children. If this were true, the more individuals in a given community desire children, the more likely they are both to marry, and to marry early, other things equal. These factors would lead one to predict a positive partial correlation between numbers of children per married woman and the fraction of the population married. To test this prediction, a variable measuring the proportion of women aged 14+ who were married in 1960 was entered in the CEB35 regressions. The results were surprising and disappointing; the effect of the marriage variable was very weak, and, if anything, the coefficient had a tendency to be negative.[2]

When the marriage variable was entered in the EXPED regressions it was found that the proportion married is strongly negatively related to EXPED.[3] This result points up the "political" component of EXPED, that is, the greater the proportion of unmarried people in a community (and presumably the fewer children per person) the less likely that community is to vote in large public school expenditures.

A second topic of interest concerns the interaction between numbers of children and quality per child. Certain variables that are not entered in the regression equations may affect the implicit prices

---

[1]See Becker (1971) and Freiden (1971).

[2]The coefficient for the marriage variable in the CEB35 regressions is -0.001 and the t-ratio 1.1. The remaining variables gave very similar results to those in Table 5, Equations (1) and (2).

[3]The marriage coefficient in the EXPED regression is -.02 and the t-ratio 4.0.

of numbers and quality in opposite directions, producing a negative correlation between the residuals of these regressions. The most obvious variable in this class is birth control knowledge. High levels of birth control knowledge should reduce the price of quality relative to numbers, other things the same. Under the assumption that this was the only major "missing variable," a simple correlation was calculated between the residuals from a CEB35 regression and those of an EXPED regression. The result, -0.06, can be interpreted to mean that differences in birth control knowledge are not a factor in establishing the relative prices of quantity and quality holding other factors constant. Unfortunately there is an alternative, equally plausible explanation, that the "left out variable" is correlated with the included variables and thus is not present in the residuals. Without a great deal of further work, it is not possible to distinguish between these explanations. One can conclude only that the data offer no support for the contention that differences in birth control knowledge are of major importance in fertility decisions.

BIBLIOGRAPHY

Allen, R. D. G., *Mathematical Analysis for Economists*, St. Martin's Press, Inc., New York, 1967.

Becker, Gary S., "A Theory of the Allocation of Time," *Economic Journal*, 75, September 1965, 493-517.

-----, "An Economic Analysis of Fertility," in *Demographic and Economic Change in Developed Countries*, A Conference of the Universities - National Bureau Committee on Economic Research, Princeton University Press, Princeton, 1960.

-----, "A Theory of Marriage," University of Chicago, 1971 (mimeo.).

Ben-Porath, Yoram, *Fertility in Israel, An Economist's Interpretation: Differentials and Trends 1950-1970*, RM-5981-FF, The Rand Corporation, Santa Monica, August 1970.

-----, "The Production of Human Capital and the Life Cycle of Earnings," *Journal of Political Economy*, 75:4, Part I, August 1967, 352-365.

Cohen, Malcolm S., Samuel A. Rea, and Robert J. Lerman, "A Micro Model of Labor Supply," BLS Staff Paper No. 4, U.S. Department of Labor, Bureau of Labor Statistics, Washington, D.C., 1970.

DaVanzo, Julie, *Family Formation in Chile, 1960*, R-830-AID, The Rand Corporation, Santa Monica, December 1971.

De Tray, Dennis N., "An Economic Analysis of Quantity-Quality Substitution in Household Fertility Decision," P-4449, The Rand Corporation, Santa Monica, August 1970.

-----, "The Substitution Between Quantity and Quality of Children in the Household," Ph.D. dissertation, University of Chicago, March 1972.

Farrar, Donald E. and R. R. Glauber, "Multicollinearity in Regression Analysis: The Problem Revisited," *Review of Economics and Statistics*, 49, February 1967, 99-107.

Freiden, Alan, "A Model of Marriage and Fertility," Ph.D. dissertation, University of Chicago, 1972.

Ghez, Gilbert, "A Theory of Life Cycle Consumption," Ph.D. dissertation, Columbia University, 1970.

Grossman, Michael, "The Demand for Health: A Theoretical and Empirical Investigation," Ph.D. dissertation, Columbia University, 1970.

Grossman, Michael, "The Economics of Joint Production in the Household," Report 7145, Center for Mathematical Studies in Business and Economics, University of Chicago, September 1971.

Hanoch, Gioria, "An Economic Analysis of Earnings and Schooling," *Journal of Human Resources*, 2, Summer 1969, 310-329.

Harman, A. J., *Fertility and Economic Behavior of Families in the Philippines*, RM-6385-AID, The Rand Corporation, Santa Monica, September 1970.

Lancaster, Kelvin J., "A New Approach to Consumer Theory," *Journal of Political Economics*, 75, April 1966, 132-157.

Leibowitz, Arleen, "Education and the Allocation of Women's Time," National Bureau of Economic Research, 1972 (mimeo.).

Malthus, Thomas, *An Essay on the Principle of Population as it Affects the Future Improvement of Society*, J. Johnson, London, 1798.

Michael, Robert T., "Education and the Derived Demand for Children," University of California at Los Angeles, 1970 (mimeo.).

-----, "The Effect of Education on Efficiency in Consumption," Ph.D. dissertation, Columbia University, 1969.

Mincer, Jacob, "Education, Experience and the Distribution of Earnings and of Employment," National Bureau of Economic Research, 1971 (mimeo.).

Moeller, John Francis, "Household Budget Responses to Negative-Tax Simulations," Ph.D. dissertation, University of Wisconsin, 1970.

Nerlove, Marc and T. Paul Schultz, *Love and Life Between the Censuses: A Model of Family Decision Making in Puerto Rico, 1950-1960*, RM-6322-AID, The Rand Corporation, Santa Monica, September 1970.

Ofek, H., "Allocation of Time in a Family Context," Ph.D. dissertation, Columbia University, 1972.

O'Hara, Donald J., *Changes in Mortality Levels and Family Decisions Regarding Children*, R-914-RF, The Rand Corporation, Santa Monica, February 1972.

Reid, Margaret G., *Economics of Household Production*, John Wiley and Sons, New York, 1934.

-----, *Housing and Income*, University of Chicago Press, Chicago, 1962.

Schultz, T. Paul, *A Family Planning Hypothesis: Some Empirical Evidence from Puerto Rico*, RM-5405-RC/AID, The Rand Corporation, Santa Monica, December 1967.

Schultz, T. Paul, "An Economic Model of Family Planning and Fertility," *Journal of Political Economy*, 77:2, March/April 1969, 153-181.

-----, *Evaluation of Population Policies: A Framework for Analysis and Its Application to Taiwan's Family Planning Program*, R-643-AID, The Rand Corporation, Santa Monica, June 1971.

-----, *Population Growth and Internal Migration in Colombia*, RM-5765-RC/AID, The Rand Corporation, Santa Monica, July 1969.

----- (assisted by Julie DaVanzo), *Fertility Patterns and Their Determinants in the Arab Middle East*, RM-5978-FF, The Rand Corporation, Santa Monica, May 1970.

Smith, James P., "Labor Supply Decisions in the Life Cycle," Ph.D. dissertation in progress, University of Chicago, 1972.

Stigler, George, "The Economics of Information," *Journal of Political Economy*, 49, June 1961, 213-215.

Sutton, Gordon F. and Gooloo S. Wunderlich, "Estimating Fertility Rates by Educational Attainment Using a Survey of New Mothers," *Demography*, 7, October 1967, 135-141.

U.S. Department of Commerce, Bureau of the Census, *Census of Population: 1960*, Vol. 1, *Characteristics of the Population*, Parts 2-52, Washington, D.C., 1963.

-----, *County and City Data Book, 1962* (A Statistical Abstract Supplement), Washington, D.C., 1962.

U.S. Department of Health, Education and Welfare, Social Security Administration, Office of Research and Statistics, *Workers Under Social Security, 1960*, Washington, D.C., 1968.

Welch, Finis, "Measuring the Quality of Schooling," *American Economic Review* (supplement), 56, May 1966, 379-392.

Wilensky, H., "Women's Work: Economic Growth, Ideology, Structure," *Industrial Relations*, 7, May 1968, 235-248.

Willis, Robert J., "A New Approach to the Economic Theory of Fertility," National Bureau of Economic Research, 1969 (mimeo.).

----- and Warren W. Sanderson, "Is Economics Relevant to Fertility Behavior?" National Bureau of Economic Research, 1970 (mimeo.).